INDUSTRIAL RESEARCH & DEVELOPMENT

NOVEMBER 1982

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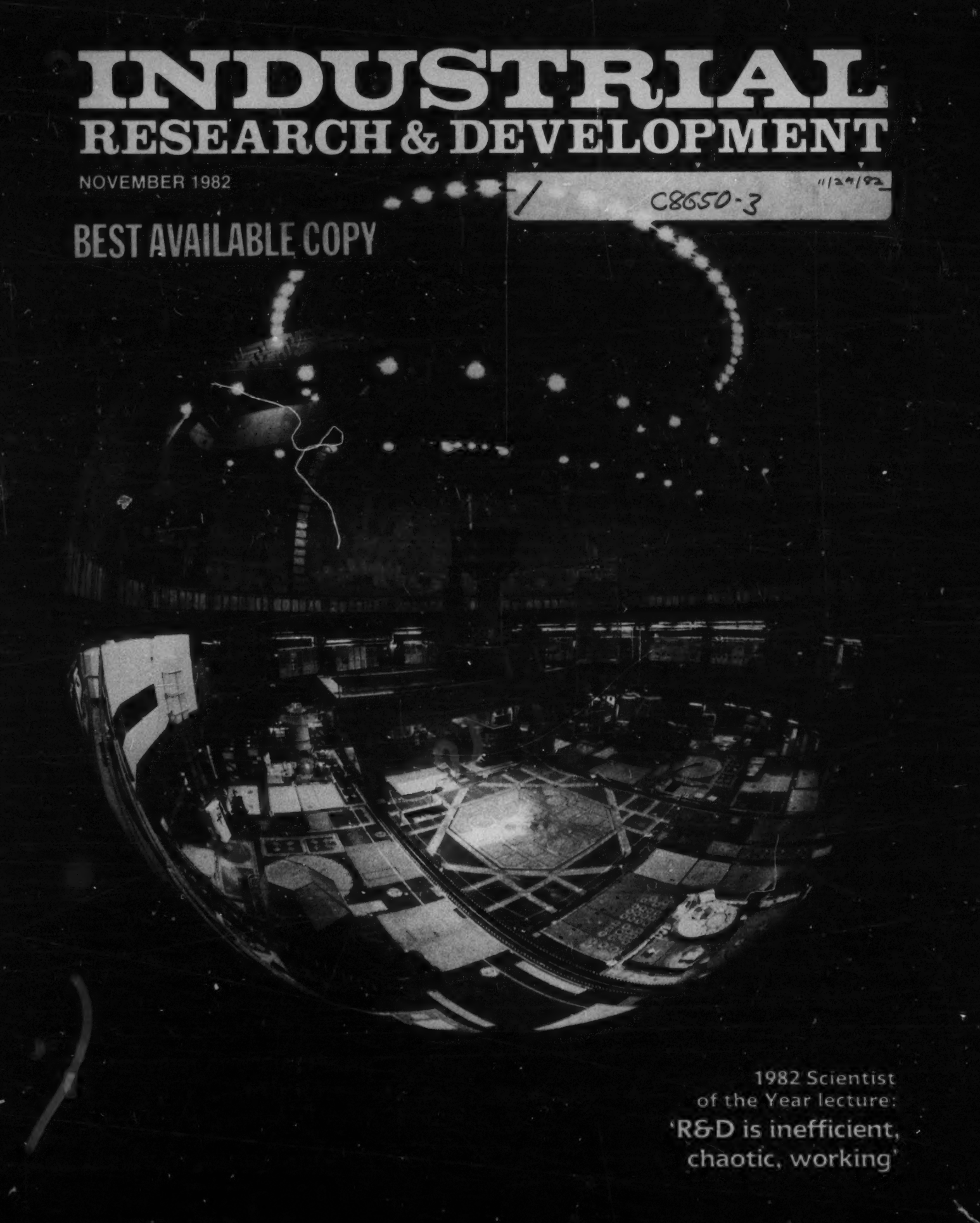

1982 Scientist of the Year lecture:

'R&D is inefficient, chaotic, working'

Ultrasound hologram images. See p 101.

INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $156.7-BILLION WORLDWIDE R&D INDUSTRY

EDITORIAL

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ABOUT THE COVER

The Fast Flux Test Facility (FFTF) provides scientists and engineers the conditions typical of those in and around a nuclear reactor. These people then can conduct realistic testing on advanced nuclear fuels and materials.

This testing, and the experience that is gained in operating a nuclear reactor, help scientists and engineers to improve designs and operating systems for future breeder reactors.

Major operations at the FFTF are carried out from the operating floor shown on the cover.

The FFTF, which began routine operation in April 1982, is managed by Westinghouse Hanford Co. for the Dept. of Energy.

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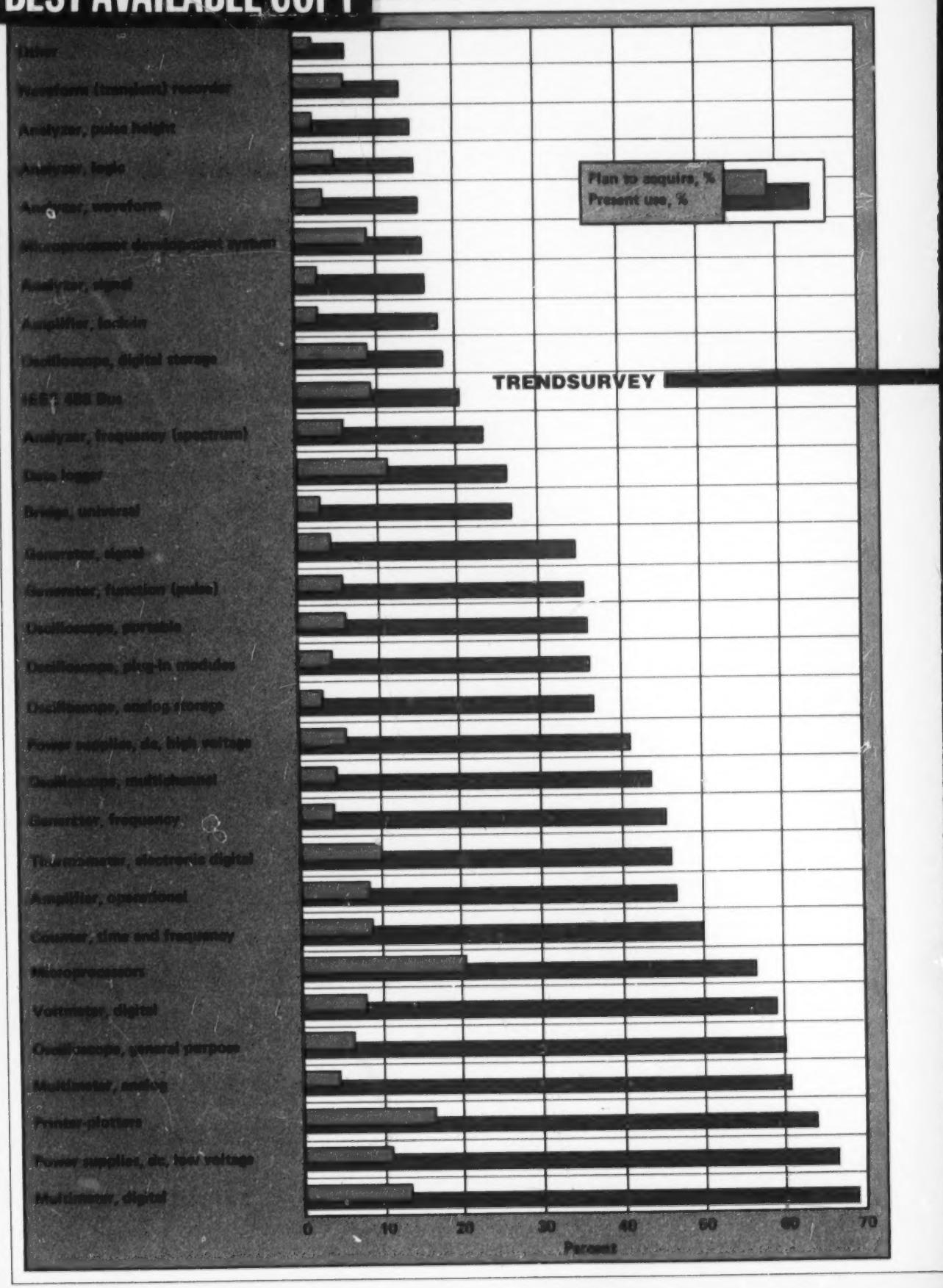


C.J. Mosbacher
Executive Editor

Use of electrical and electronic instruments

Overall plans to acquire bound back from last year's low point and even exceed 1980 highs, despite lower average plans to acquire new instruments in the university sector and by the physical scientists.

IF YOU ACCEPT plans to acquire averaged over some 30 instrument types as a leading indicator of capital investment in electrical and electronic instruments for R&D, that investment will leap almost 13% in the year ending next June. Last year, plans to acquire indicated by respondents to the *IR&D* Trendsurvey dropped almost 10%, from 6.8% of respondents in 1980 to 6.2%. This year, the average plans to acquire within one year jump to 7.0%.

Contrasting to last year, however, the engineering segment grew while representation of physical scientists declined. Engineers normally are larger users and purchasers of electrical and electronic instruments. Our conclusion last year was that plans to acquire probably would fall in actual terms only about 2% because of adjustments for demographic changes.

Our interpretation of this year's results is that plans to acquire on average, adjusted for demographic changes, indicate an increase in instrument acquisitions through next June of 9% to 10%. One mitigating factor is that while planned acquisitions increase in the industrial sector but decrease in the university sector, representation of industry decreases and that of the university segment increases. Thus one demographic change tends to balance out the other, which was not the case in the 1981 Trendsurvey.

Another factor indicating a better year ahead is that the portion of respondents who have no plans to acquire any instruments at all within one year falls almost 7% from last year to this, from 47.7% to 44.4%.

Present use of electrical and electronic instruments, averaged over the 30 specific instruments listed in the Trendsurvey, grows 11.5% over last year, from 33.2% to 37.0%. Those not using any instruments, although planning to acquire at least one, drops from 3.2% to 3.0%.

Generally, the trend toward digital instrumentation is confirmed once again, although digital voltmeters lead the list of losers in plans to acquire. For example, digital multimeters rise from 12.2 to 13.2%, while plans to acquire analog multimeters decline slightly from last year. Digital storage oscilloscopes gain almost 3 percentage points while the analog counterparts drop half a point.

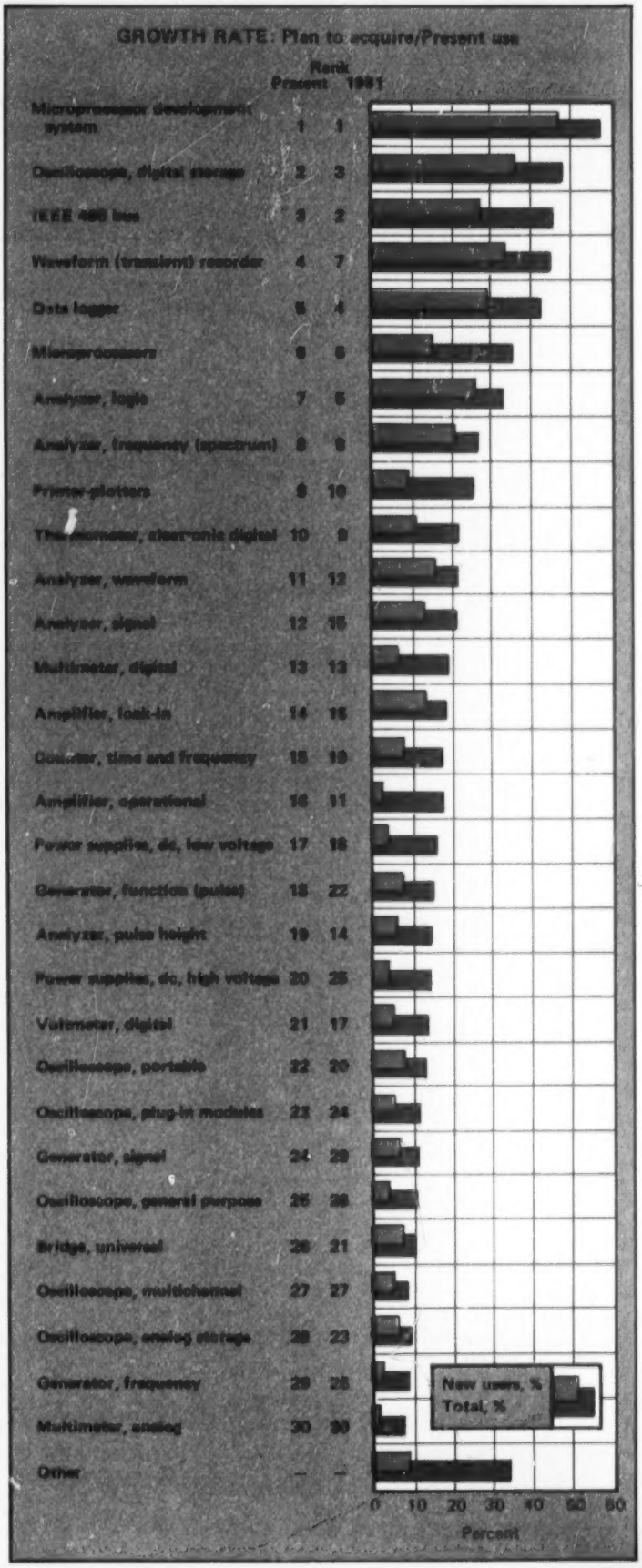
In present use, all except one category, pulse height analyzers, show gains from last year. Tied for the lead with a 6.8 point lead are frequency generators and multichannel oscilloscopes.

In plans to acquire, 19 categories are up, 2 are the same, and 10 are down from last year. The leading gainer is digital storage oscilloscopes, with time and frequency counters, printer-plotters, and waveform (transient) recorders all showing a 1.9 point gain to tie for second. The biggest loser, as noted earlier, is digital voltmeters, but it lost only 1.4 points. Second biggest loser, at 0.8 point, is operational amplifiers; pulse height analyzers is third, with a 0.7 point loss.

For growth rate, which combines the gains or losses of both present use and plans to acquire because the rate is calculated by dividing plans to acquire by present use, the biggest gainer is waveform (transient) recorders, with a 10.9 point gain to 45.2% from 34.3% last year. Logic analyzers gain 8.1 points for second place.

Largest losers in growth rate are operational amplifiers at 4.6 points and pulse height analyzers at 4.5 points.

Results of the Trendsurvey are presented graphically on these pages. Present


GROWTH RATE: Plan to acquire/Present use
Rank
Present 1981
Microprocessor development system 1 1
Oscilloscope, digital storage 2 3
IEEE 488 bus 3 2
Waveform (transient) recorder 4 7
Data logger 5 4
Microprocessors 6 6
Analyzer, logic 7 5
Analyzer, frequency (spectrum) 8 9
Printer-plotters 9 10
Thermometer, electronic digital 10 8
Analyzer, waveform 11 12
Analyzer, signal 12 15
Multimeter, digital 13 13
Amplifier, lock-in 14 16
Counter, time and frequency 15 19
Amplifier, operational 16 11
Power supplies, dc, low voltage 17 18
Generator, function (pulse) 18 22
Analyzer, pulse height 19 14
Power supplies, dc, high voltage 20 25
Voltmeter, digital 21 17
Oscilloscope, portable 22 20
Oscilloscope, plug-in modules 23 24
Generator, signal 24 29
Oscilloscope, general purpose 25 28
Bridge, universal 26 21
Oscilloscope, multichannel 27 27
Oscilloscope, analog storage 28 23
Generator, frequency 29 26
Multimeter, analog 30 30
Other – –
New users, %
Total, %
0 10 20 30 40 50 60
Percent

use and plans to acquire are graphed as a percent of the total number of respondents on the first page. Growth rates are summarized in the chart on this page, which gives the total growth rate and the rate for new users—those who indicated they do not presently use an instrument but who plan to acquire it in the next year. Rankings this year and last are also given on the growth rate chart. Complete data giving numbers of respondents as well as percentages for the total sample and disciplines are given in the table on the facing page of this article for both growth and growth rate.

As can be calculated from data in the table, 52.6% of respondents gave engineering as their primary discipline, 35.7% physical science, and 9.3% life science or medicine. In 1981, the corresponding breakdown by discipline was 45.3%, 42.0%, and 10.8%, respectively.

By employer, 57.8% of respondents work in industry, 18.6% in universities, 6.3% in nonprofit organizations, 2.4% in medical research centers, and 12.3% in other areas including government. In 1981, the corresponding numbers were 60.0%, 17.3%, 6.3%, 2.0%, and 12.1%.

By job function, 4.3% are corporate officers, 7.3% R&D executives, 15.8% project management, 65.7% professional staff, and 5.8% other. The 1981 numbers were 4.9%, 7.1%, 16.5%, 66.2%, and 4.0%. Note that as with the other demographic data, the totals are less than 100% because some respondents did not answer all questions.

In geographic terms, the distribution of respondents correlates well with the *IR&D* circulation, which in turn correlates with R&D activity in the United States. New England accounts for 7.6% of this year's respondents, the Middle Atlantic 17.1%, East North Central 16.4%, West North Central 4.3%, South Atlantic 12.9%, East South Central 3.1%, West South Central 7.0%, Mountain 5.5%, and Pacific 17.5%.

Average present use and plans to acquire (without "Other") varied among demographic groups. By discipline, the averages were 43.2% and 8.7% for engineering, 31.9% and 5.2% for physical science, and 22.9% and 4.3% for life science or medicine.

Corporate officers have average present use of 38.1% and average plans to acquire of 9.3%, R&D executives 38.1% and 9.7%, project managers 40.6% and 7.9%, professional staff 35.5% and 6.3%, and other 41.8% and 6.9%.

By employer, industry averages 35.1% for present use and 6.9% for plans to acquire, universities 39.8% and 6.8%, nonprofit organizations 41.9% and 10.2%, medical research centers 39.8% and 8.7%, and other, including government, 39.1% and 6.0%.

As with earlier Trendsurveys, this study was conducted by including a prepaid reply postcard in a mailing to domestic *IR&D* subscribers in late May. By early August, 1,198 cards that provide the data included here had been returned. □

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PRESENT AND PLANNED USE — Data from 1,198 respondents

	Use now								Plan to acquire within 1 year								Growth rate = plan to acquire ÷ present use			
	Total, 1,198		Engineering, 630		Physical science, 428		Life science or medicine, 111		Total, 1,198		Engineering, 630		Physical science, 428		Life science or medicine, 111		Total	Present users who plan to acquire		New users
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	%	No.	%	%
Amplifier, lock-in	213	17.8	89	14.1	110	25.7	8	7.2	40	3.3	19	3.0	17	4.0	2	1.8	18.8	12	5.6	13.1
1981		16.1								2.6										
Amplifier, operational	566	47.2	342	54.3	181	42.3	30	27.0	97	8.1	65	10.3	23	5.4	4	3.6	17.1	84	14.8	2.3
1981		41.1								8.9										
Analyzer, frequency (spectrum)	278	23.2	189	30.0	64	15.0	19	17.1	75	6.3	51	8.1	20	4.7	2	1.8	27.0	19	6.8	20.1
1981		22.7								6.4										
Analyzer, logic	173	14.4	133	21.1	27	6.3	10	9.0	57	4.8	46	7.3	9	2.1	2	1.8	32.9	11	6.4	26.6
1981		12.5								5.0										
Analyzer, pulse height	168	14.0	66	10.5	82	19.2	15	13.5	24	2.0	13	2.1	9	2.1	2	1.8	14.3	14	8.3	6.0
1981		14.4								2.7										
Analyzer, waveform	183	15.3	134	21.3	36	8.4	6	5.4	30	3.3	30	4.8	7	1.6	1	0.9	21.3	11	6.0	15.3
1981		12.4								2.6										
Analyzer, signal	194	16.2	127	20.2	50	11.7	10	9.0	40	3.3	27	4.3	9	2.1	4	3.6	20.6	15	7.7	12.9
1981		14.9								2.5										
Bridge, universal	321	26.8	218	34.6	83	19.4	11	9.9	32	2.7	25	4.0	6	1.4	1	0.9	10.0	10	3.1	6.9
1981		22.5								2.9										
Counter, time and frequency	598	49.9	376	59.7	174	40.7	36	32.4	104	8.7	66	10.5	29	6.8	6	5.4	17.4	60	10.0	7.4
1981		46.0								6.6										
Data logger	313	26.1	183	29.0	97	22.7	25	22.5	132	11.0	86	13.7	34	7.9	8	7.2	42.2	41	13.1	29.1
1981		23.1								9.4										
Generator, frequency	542	45.2	367	58.3	147	34.3	20	18.0	48	4.0	37	5.9	8	1.9	1	0.9	8.9	37	6.8	2.0
1981		38.4								4.4										
Generator, function (pulse)	427	35.6	285	45.2	114	26.6	20	18.0	63	5.3	40	6.3	20	4.7	2	1.8	14.8	31	7.3	7.5
1981		31.9								4.0										
Generator, signal	413	34.5	282	44.8	105	24.5	15	13.5	45	3.8	33	5.2	8	1.9	2	1.8	10.9	20	4.8	6.1
1981		29.4								2.8										
IEEE 488 Bus	246	20.5	157	24.9	77	18.0	10	9.0	112	9.3	71	11.3	33	7.7	7	6.3	45.5	44	17.9	27.6
1981		15.5								7.6										
Microprocessors	678	56.6	376	59.7	237	55.4	53	47.7	243	20.3	134	21.3	80	18.7	21	18.9	35.8	139	20.5	15.3
1981		55.4								20.6										
Microprocessor development system	189	15.8	139	22.1	40	9.3	7	6.3	106	8.8	70	11.1	24	5.6	8	7.2	56.1	29	15.3	40 7
1981		14.5								7.9										
Multimeter, analog	728	60.8	429	68.1	246	57.5	42	37.8	53	4.4	40	6.3	10	2.3	1	0.9	7.3	45	6.2	1.1
1981		54.4								4.5										
Multimeter, digital	829	69.2	495	78.6	279	65.2	41	36.9	158	13.2	104	16.5	43	10.0	6	5.4	19.1	106	12.8	6.3
1981		64.0								12.2										
Oscilloscope, analog storage	439	36.6	290	46.0	121	28.3	20	18.0	40	3.3	27	4.3	10	2.3	1	0.9	9.1	15	3.4	5.7
1981		30.6								3.8										
Oscilloscope, digital storage	221	18.4	150	23.8	55	12.9	9	8.1	105	8.8	77	12.2	20	4.7	6	5.4	47.5	25	11.3	36.2
1981		14.3								6.0										
Oscilloscope, general purpose	719	60.0	436	69.2	226	52.8	42	37.8	76	6.3	51	8.1	19	4.4	3	2.7	10.6	49	6.8	3.8
1981		55.5								5.3										
Oscilloscope, multichannel	523	43.7	356	56.5	135	31.5	21	18.9	51	4.3	40	6.3	9	2.1	—	—	9.8	27	5.2	4.6
1981		36.9								4.1										
Oscilloscope, plug-in modules	433	36.1	280	44.4	127	29.7	16	14.4	48	4.0	30	4.8	14	3.3	2	1.8	11.1	27	6.2	4.8
1981		33.6								4.0										
Oscilloscope, portable	430	35.9	292	46.3	111	25.9	15	13.5	55	4.6	39	6.2	13	3.0	1	0.9	12.8	21	4.9	7.9
1981		30.6								4.1										
Power supplies, dc, high voltage	488	40.7	243	38.6	190	44.4	40	36.0	69	5.8	45	7.1	20	4.7	3	2.7	14.1	51	10.5	3.7
1981		38.4								4.5										
Power supplies, dc, low voltage	799	66.7	481	76.3	250	58.4	51	45.9	128	10.7	83	13.2	37	8.6	4	3.6	16.0	102	12.8	3.3
1981		60.4								9.5										
Printer-plotters	769	64.2	390	61.9	300	70.1	69	62.2	196	16.4	106	16.8	64	15.0	23	20.7	25.5	125	16.3	9.2
1981		58.0								14.5										
Thermometer, electronic digital	552	46.1	326	51.7	174	40.7	42	37.8	120	10.0	71	11.3	36	8.4	9	8.1	21.7	62	11.2	10.5
1981		40.5								10.0										
Voltmeter, digital	708	59.1	431	68.4	214	50.0	48	43.2	92	7.7	57	9.0	26	6.1	6	5.4	13.0	58	8.2	4.8
1981		57.5								9.1										
Waveform (transient) recorder	157	13.1	94	14.9	49	11.4	10	9.0	71	5.9	52	8.3	13	3.0	4	3.6	45.2	19	12.1	33.1
1981		11.7								4.0										
Other	76	6.3	36	5.7	32	7.5	7	6.3	26	2.2	14	2.2	10	2.3	2	1.8	34.2	19	25.0	9.2
1981		6.0								2.1										

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CIRCLE **257** ON INQUIRY CARD

OPINION POLL RESULTS

Few limits to speech in R&D

FREEDOM of speech, as it applies to the communication of scientific information, is not a major concern for readers of this magazine, if respondents to the Opinion Poll survey on that subject are typical. To begin with, we received just under 1,400 responses, the lowest Opinion Poll response for any subject in many years.

Of the respondents, 45% have not experienced regulations limiting the communication of scientific information in their current jobs or the previous ones. While 43% have experienced such limitations on their current jobs and 26% on their previous jobs, only 14% have had that experience on both jobs.

Of those who answered "yes" to question No. 1, 87% believe that their work has benefitted from exchanges of scientific information, while only 76% of those answering "no" believe that. And 22% of those answering "yes" say they know of other people's exchanges of scientific information that may have compromised national security.

Complete results of the survey follow:

1. *Have you experienced regulations limiting the communication of scientific information?*
   a. Yes, in current job 29% c. Yes, in both.... 14%
   b. Yes, previous job . 12 d. No..... 45
2. *Within your knowledge of the situation(s), did these regulations seem to be*
   a. Essential..... 24% d. Futile 9%
   b. Desirable ..... 27 e. Only a nuisance 16
   c. Okay ..... 15 f. Harmful 9
3. *Do you believe that restricting the exchange of scientific information will prevent other countries from obtaining it?*
   a. Yes ..... 19% b. No..... 65%
   c. Don't know 16
4. *Do you think that restricting scientific information will significantly delay other countries which eventually would obtain it?*
   a. Yes ..... 56% b. No..... 30%
   c. Don't know 14
5. *Has your work benefitted from exchanges of scientific information?*
   a. A lot ..... 45% c. Don't know..... 8%
   b. A little..... 36 d. No..... 11
6. *Do you feel that your work probably will benefit from scientific exchange in the future?*
   a. A lot ..... 45% c. Don't know 12%
   b. A little..... 36 d. No..... 7
7. *Do you believe that national security has been compromised in your exchanges?*
   a. Yes..... 3% b. No..... 90%
   c. Don't know 7
8. *Do you know of other people's exchanges of scientific information which you feel may have compromised security?*
   a. Yes ..... 18% b. No..... 82%
9. *Have you been asked by an agency of the U.S. government to report scientific contacts with foreign nationals?*
   a. Often..... 9% b. Once..... 8%
   c. No. 83

INDUSTRIAL RESEARCH & DEVELOPMENT

JANUARY 1983

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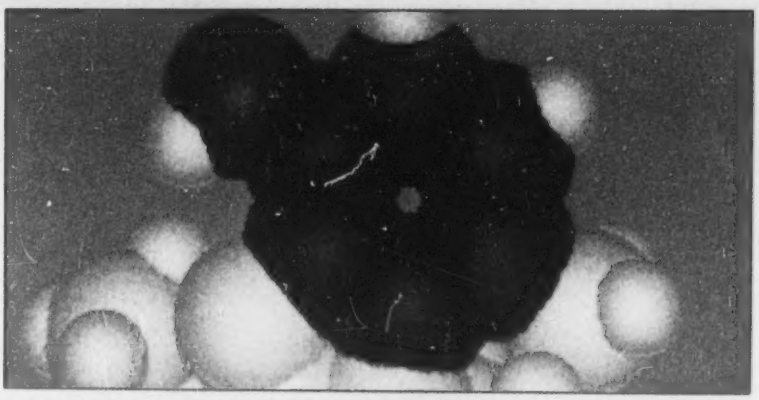
Prospects for R&D funding in 1983

Software — more uses, more profit

News of importance to people in R&D

Software aids for chemists and engineers.
See pp 74, 80.



INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $156.7-BILLION WORLDWIDE R&D INDUSTRY

EDITORIAL

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ABOUT THE COVER

Twin plasma torches heat quartz in the manufacture of discharge tubes for commercial electric lamps. The high-temperature plasma quickly heats the quartz to its softening temperature.

The new torch system was designed by General Electric Co. to replace hydrogen-oxygen torches in lamp-forming machines. The cost of the nitrogen and the electricity is about 25% of the fuel costs for hydrogen-oxygen torches.

The finished quartz product is of higher quality than products made with earlier torches because there is less oxidation of metal parts, such as leads, and less water vapor is introduced into the lamps. Water formed by the reaction of hydrogen and oxygen can cause premature failure in all kinds of lamps.

The plasma torch provides a clean flame that transfers heat quickly and efficiently to the workpiece. Photo courtesy General Electric.

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NEWS OF SCIENCE AND TECHNOLOGY

41 **Nuclear:** Debate over nuclear licensing reform heats up

42 **Space:** Astronomers find evidence of methane in the solar system beyond Earth; Antarctic meteorite is believed to be from the Moon; *Columbia's* successful mission launches the era of space commerce

46 **Computers:** Benefits of parallel processing fuel supercomputer research; Caltech researchers find and assess acid fog

48 **Chemistry:** Copolymer research finds solar energy uses promising

50 **R&D funding:** Private, state universities grapple with shrinking budgets

54 **Awards:** *I•R 100* competition continues; final call for Laboratory of the Year entries

56 **Survey:** *IR&D* to study instrument purchases

58 **Cinematography:** Datakode film combines magnetic and image recording

60 **Monitoring:** Highly instrumented platform will aid the design of offshore structures; sensor can detect ash clouds 60 miles ahead of aircraft

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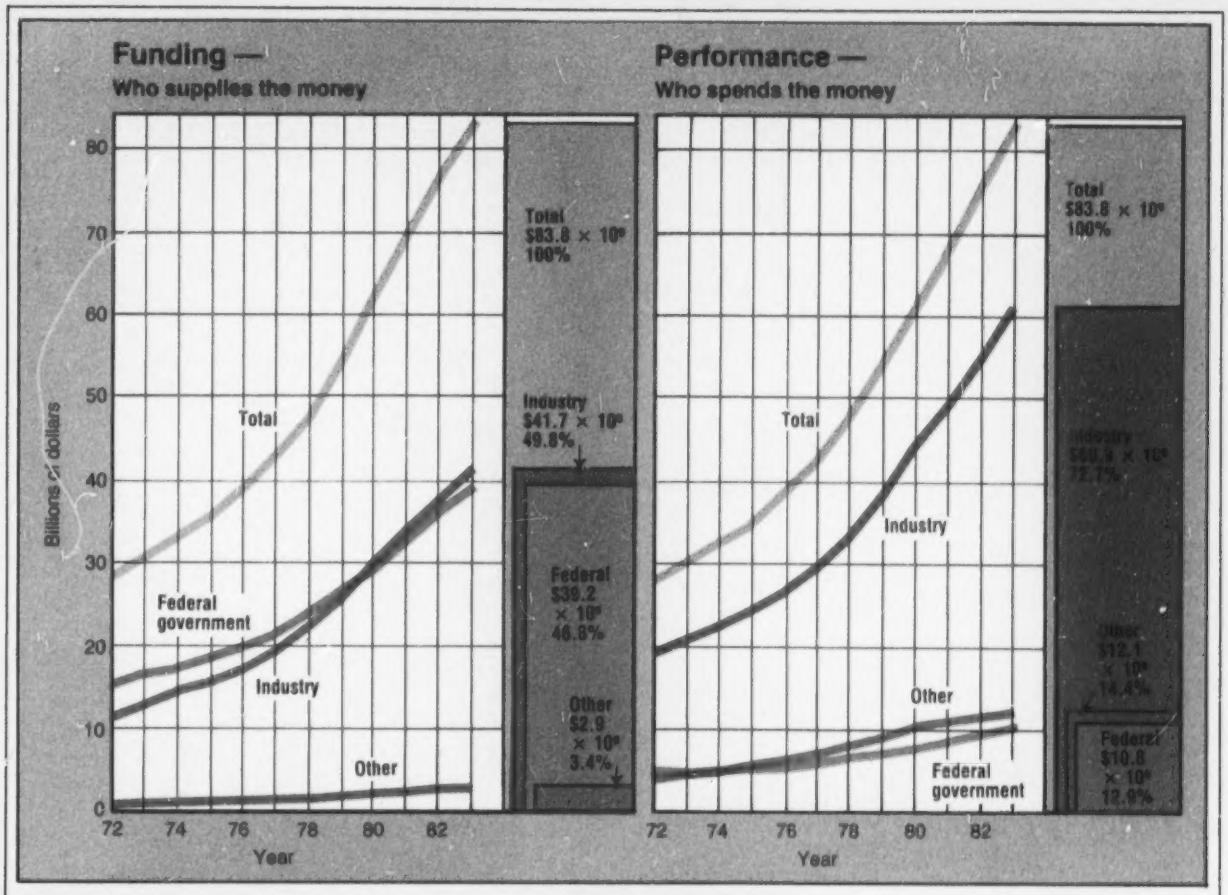


Funds for R&D will climb 9% to $83.8 billion in '83

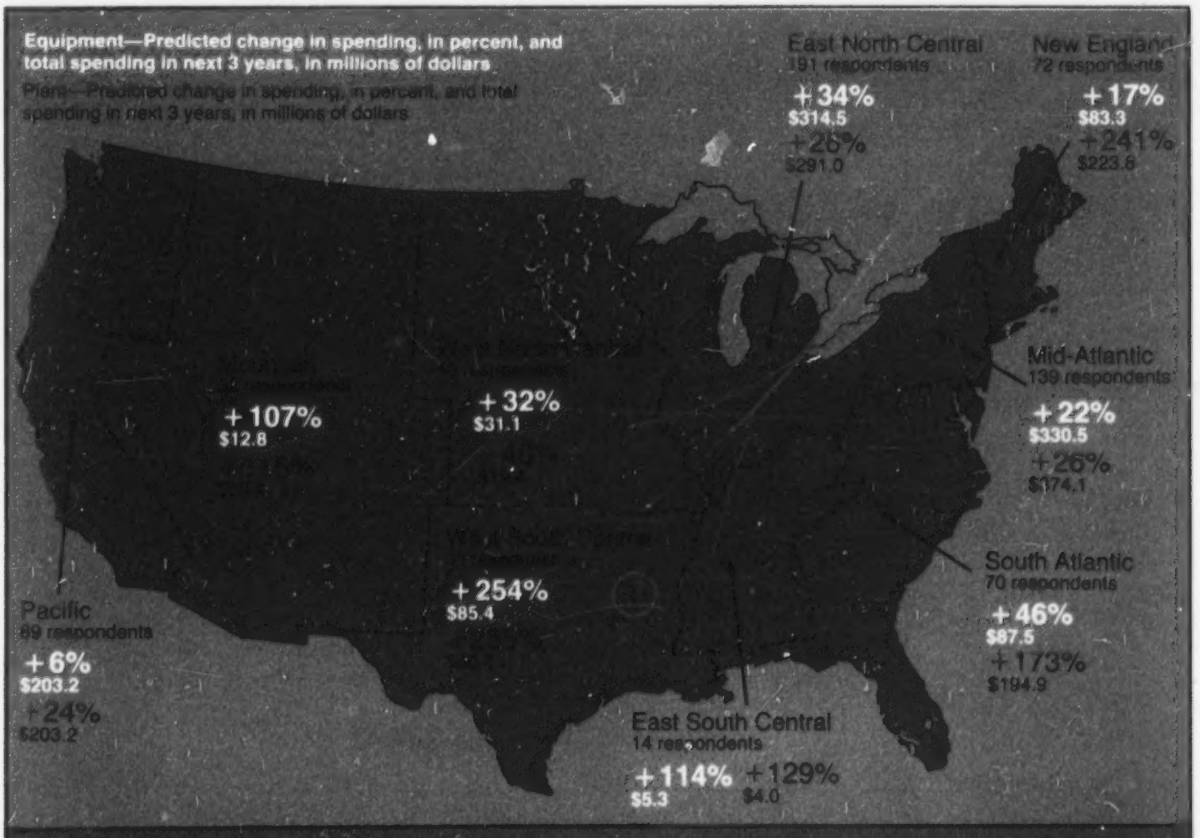
C.J. Mosbacher
Executive Editor

Despite recession-induced curbs on industry increases, congressional delays in the appropriations needed for fiscal 1983, and a near-disaster in the educational sector, a lower inflation rate should make real growth in R&D possible this year.

CONSIDERING the condition of the general economy, any real growth in R&D funding is encouraging. Thus our forecast that $83.8 billion will be spent for R&D in 1983 should be cheery news. But the cheer should be tempered by the fact that 1982 spending did not increase the 11.6% over 1981 that we forecast last January. The lower than expected 1982 spending, when used as the base for calculating increases in 1983, has the effect of raising percentages. If we use unadjusted data, the overall increase falls below 9%.

Furthermore, increases are not spread evenly over all sectors, as can be seen in the graphs at the top of this page. Industry fares best, but the educational and nonprofit organizations included in the "other" category will not get adequate money to perform as much R&D this year as in the past *unless* inflationary increases in salaries and other costs are less than the 5.2% increase our studies indicate.

The data graphed here for 1972 to 1980 are from the National Science Foundation, as are the preliminary data for 1981 (NSF 82-319, "National Patterns of Science and Technology Resources, 1982"). An



Study of industry predicts substantial increases in long-term capital spending

...with most studies of R&D funding, this *IR&D* forecast covers operating budgets, which include only that portion of capital expenses that are amortized in that particular year. A study conducted by a student group at the Univ. of Wisconsin, Madison, elicited 182 responses to a long questionnaire sent to 5,803 directors of research in industry from March to May 1982, for a response rate of 11.8%.

Major conclusions include: Capital spending for laboratory plant—bricks and mortar—will increase 60% over the next three years compared to the last three. Capital spending for laboratory equipment for the same three-year periods will show an increase of 31%. Both increases are projected from the data shown on the map above, which summarizes the data by geographic region. The basis for projection was the 11,869 industrial laboratories in the total list from which the sample was drawn.

A larger portion of the larger laboratories responded to the questionnaire, and this could skew the results slightly. One quarter of the respondents account for more than three quarters of all anticipated capital expenditures.

The study also gives data on projected capital expenditures by industrial sector, reasons for increased capital expenditures, size of laboratories and relation to other facilities.

The complete study is available for $45 from the firm that sponsored the study. Orders accompanied by a check should be sent to Flad & Associates, Attn: James W. Hornik, Box 5038, Madison, WI 53705.

Besides Hornik, advisors for the study included Thomas Hogan, NSF; Charles F. Larson, Industrial Research Institute; and C.J. Mosbacher, *IR&D*. Faculty advisor was Michael Houston.

IR&D revised estimate is used for 1982.

Usually, the first step in preparing the *IR&D* forecast is to adjust last year's data to agree with the latest data available from NSF. This year, however, NSF has already indicated that its 1982 data will be revised to lower levels. So we have adjusted the total for 1982 funds to $76.9 billion, with $38.0 billion provided by industry, $36.1 billion by the Federal government, and $2.8 billion by other sources. Corresponding expenditure levels for 1982 are $55.5 billion, $9.9 billion, and $11.5 billion.

These adjustments and our forecast are based on data from many sources, including off-the-record information from industry and other sectors about budgets and plans for the forthcoming year.

Industry leads increases. Even though other studies indicate that tax incentives still have little effect on R&D funding, increases in the industrial sector lead all others. Our forecast is that industry will provide 9.7% more funding in 1983. While down from the 1981 to 1982 increase, this provides comparable real growth because inflation is projected to be somewhat lower at 6%.

Last June, NSF projected industry funding at $42.6 billion as part of its estimate of $85 billion total spending in 1983 (NSF 82-311, June 11, 1982). Later, based on replies from 75 companies to a special survey, NSF reported that total company-funded expenditures could be estimated to be $37.3 billion for 1983 (NSF 82-324, Sept. 9, 1982), equivalent to a 7.9% increase from 1982. However, this survey did not include

company funding of R&D at educational institutions and other nonprofit organizations. Such funding, although small in total, has been increasing at a faster rate than other industrial funding.

Our data, gathered much later from a small number of companies, indicates more optimism and a somewhat higher level of overall industrial spending. Our forecast is that industry will provide $41.7 billion for R&D, maintaining its share of the total near half at 49.8%.

Of course not all parts of industry will contribute equally. Some, such as the energy sector, the basic metals sector, and the automotive sector, will not add enough funding to cover inflation. Conversely, sectors such as pharmaceuticals, chemicals, instruments, and electrical equipment will provide adequate funds to insure real growth.

Industry will spend 72.7% of the total funds available in 1983, or $60.9 billion. That is an increase of 9.7% over 1982, with the Federal government providing the difference between the amount industry itself provides and the total to be spent.

Late appropriations delay Federal funds. When Congress reconvened in its lame duck session in December, it still had to act on 7 of the 10 major appropriations bills, including that providing money for defense. The largest increases for R&D in the Federal budget are for defense, with much of the funding going to industry.

Until Congress acts, government funding generally continues at the level of the last fiscal year. Because of the lag between appropriation, obligation, and actual spending, the inaction of Congress has endangered plans for increased R&D spending this year. Taking this into account, we forecast Federal funding at $39.2 billion, an increase of only 8.6% over the 1982 adjusted levels.

Work in government laboratories, however, will increase 9.1% to $10.8 billion. But funds transferred to federally funded R&D centers operated by universities, and thus in the "other" category, will be held down to allow this increase in Federal laboratories dealing primarily with defense and space.

Academic sector will continue to suffer. Few bright spots are found in the universities and colleges. Our forecast is that the academic, nonprofit, and state and local funding included in the "other" category will increase only 3.6% to $2.9 billion. Transfers of funds from industry and the Federal government will raise performance levels to $12.1 billion, a 5.2% increase from 1982. Thus the chaos we noted last year in the academic sector will continue.

Hopefully, improvements in the general economy will lead to a better 1984 and a rebalancing of R&D funding. The first indicator will be the Federal budget for fiscal 1984, scheduled to be presented to the new Congress this month. □

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INDUSTRIAL RESEARCH & DEVELOPMENT

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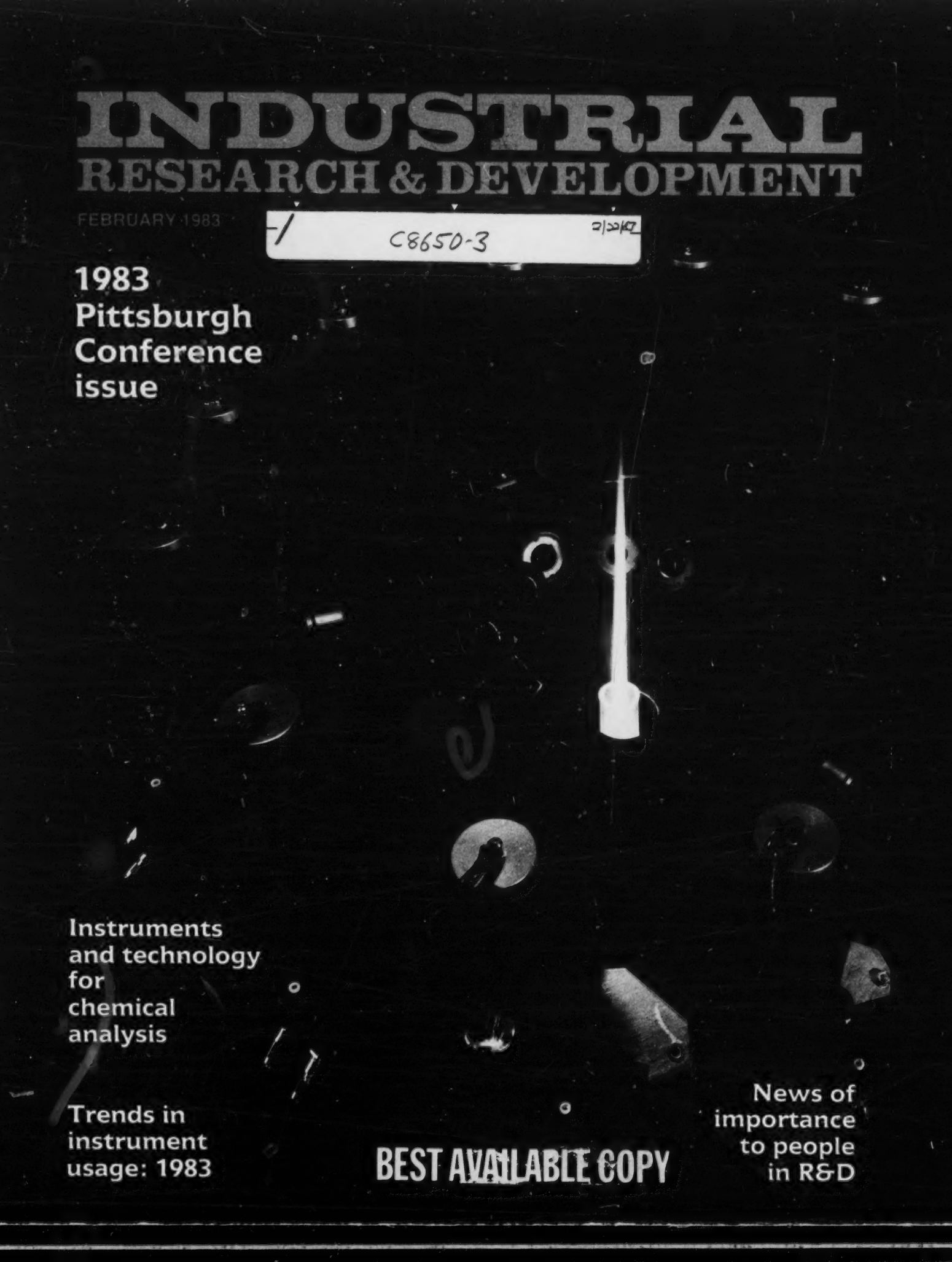
1983 Pittsburgh Conference issue



Instruments and technology for chemical analysis

Trends in instrument usage: 1983

News of importance to people in R&D

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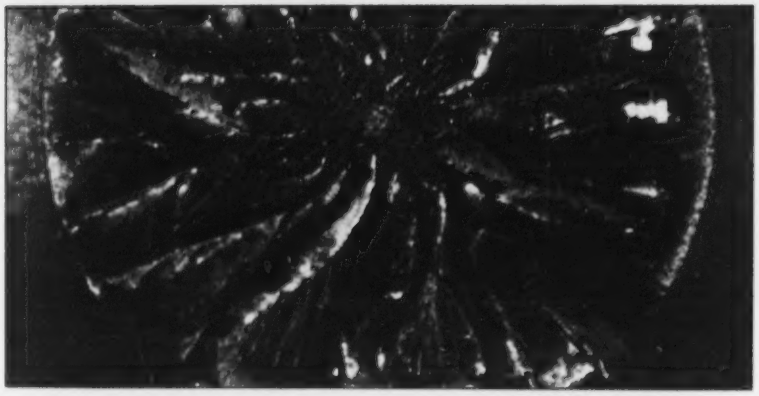
Macroscopy studies structural failure mechanism. See p. 108.



INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $156.7-BILLION WORLDWIDE R&D INDUSTRY

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ABOUT THE COVER

Twelve optical modules, each specific for one element, surround an argon inductively coupled plasma atomization cell in an atomic fluorescence spectrometer. This arrangement permits the simultaneous determination of up to 12 elements in a sample.

Typical atomic absorption can determine only one element at a time. Plasma sources offer some improvement, but stray light and broadened spectral lines often interfere to make determinations complicated.

In atomic fluorescence spectrometry, however, the plasma serves only as an atomization cell to produce ground-state atoms. The absorbed light is viewed out of the path of the optical beam. Then, atomic fluorescence occurs only at the most sensitive atomic resonance lines.

An article on atomic fluorescence spectrometry begins on p 100.

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ABP BPA

NEWS OF SCIENCE AND TECHNOLOGY

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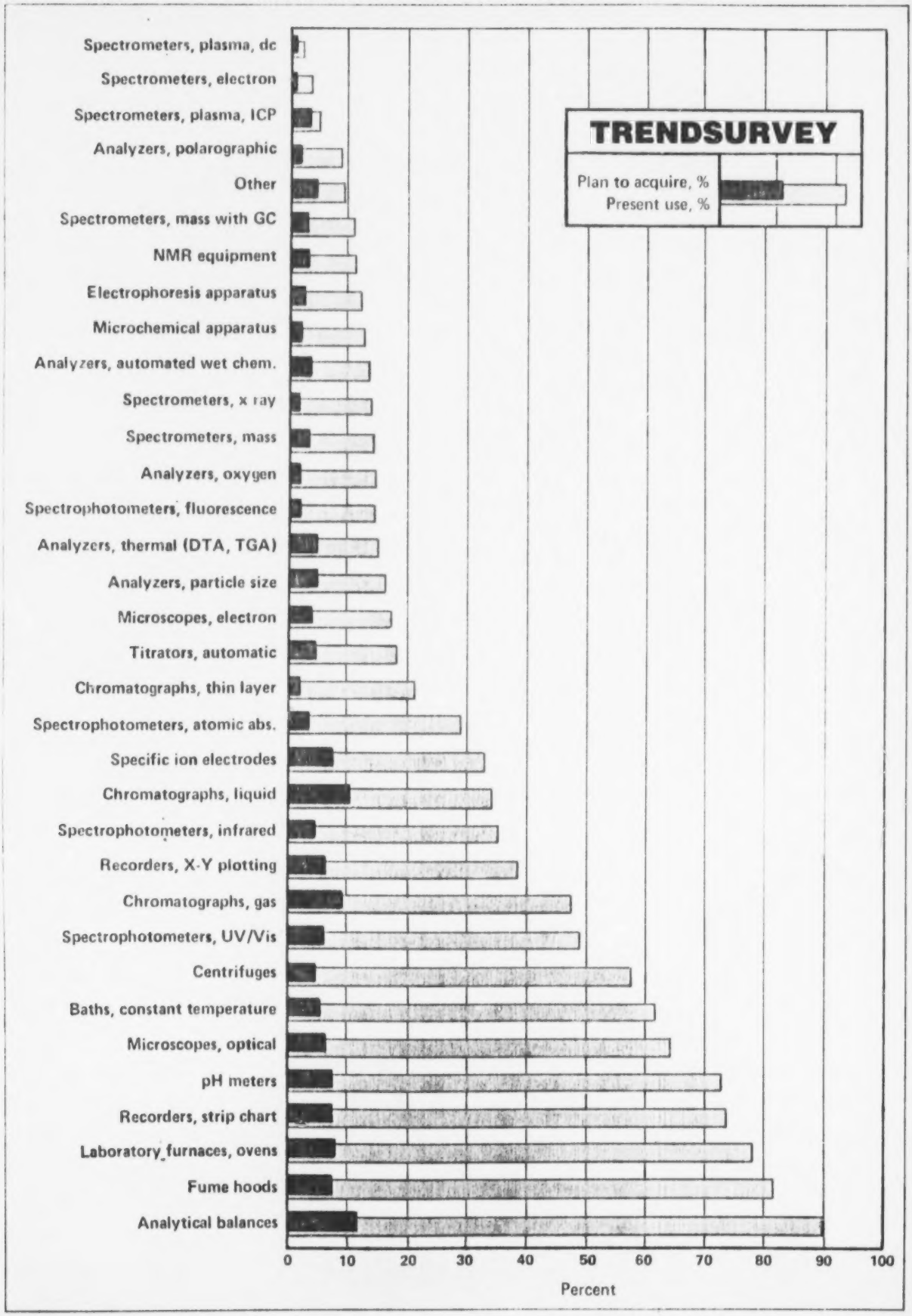

TRENDSURVEY
Plan to acquire, %
Present use, %
Spectrometers, plasma, dc
Spectrometers, electron
Spectrometers, plasma, ICP
Analyzers, polarographic
Other
Spectrometers, mass with GC
NMR equipment
Electrophoresis apparatus
Microchemical apparatus
Analyzers, automated wet chem.
Spectrometers, x ray
Spectrometers, mass
Analyzers, oxygen
Spectrophotometers, fluorescence
Analyzers, thermal (DTA, TGA)
Analyzers, particle size
Microscopes, electron
Titrators, automatic
Chromatographs, thin layer
Spectrophotometers, atomic abs.
Specific ion electrodes
Chromatographs, liquid
Spectrophotometers, infrared
Recorders, X-Y plotting
Chromatographs, gas
Spectrophotometers, UV/Vis
Centrifuges
Baths, constant temperature
Microscopes, optical
pH meters
Recorders, strip chart
Laboratory furnaces, ovens
Fume hoods
Analytical balances
0
10
20
30
40
50
60
70
80
90
100
Percent

C.J. Mosbacher
Executive Editor

Use of analytical instruments and equipment

Lower plans to acquire analytical instruments are indicated by this latest study. How much lower is masked by demographic changes in the respondents this year.

FOR THE SECOND YEAR, inductively coupled plasma (ICP) spectrometers hold top place in growth rate in the annual *IR&D* Trendsurvey of use of analytical instruments and equipment by readers, with DC plasma spectrometers in second place and liquid chromatographs in third. On a total sample basis, however, plans to acquire within one year are topped by analytical balances, with liquid chromatographs in second place; gas chromatographs, third; and laboratory furnaces and ovens, fourth.

Until last year, liquid chromatographs had led both measures of growth for nine years. Now, both types of chromatographs are in such wide use that the growth rate calculated on the basis of present use becomes lower. Conversely, growth rates for instruments such as the two types of plasma spectrometers are accentuated by their relatively small present use.

Data from the 1,735 respondents to the Trendsurvey are tabulated in this article and are presented graphically in two ways—in percent of total sample in the graph at left, and in percent of present users, or growth rate, on the next page.

Comparing results this year to last year, it is clear that plans to acquire the 33 types of instruments and equipment included in the Trendsurvey are down on average. Present use averaged over the 33 categories decreases 0.6%, from 32.7% to 32.5%. Average plans to acquire drop more drastically, from 5.2% to 4.6%, a decrease of more than 11.5%.

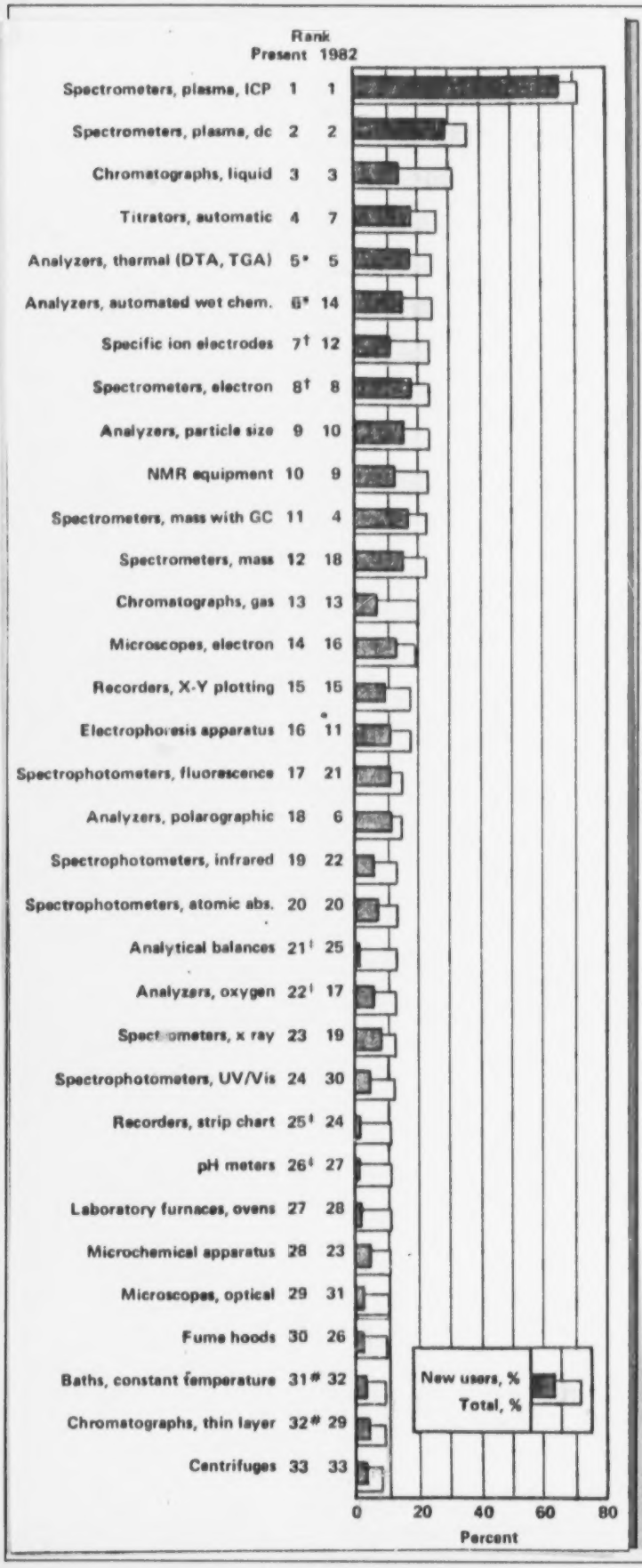
Much of the decrease, however, can be attributed to changes in the demography of the respondents to the two Trendsurveys. In the present study, respondents included more life scientists and medical researchers and fewer engineers and physical scientists. In addition, more respondents worked for universities and nonprofit organizations, while fewer worked in industry than was the case last year.

Both of these demographic changes tend to decrease average plans to acquire. When the data are normalized to account for these changes, the 11.5% decrease diminishes to a 4% decrease in plans to acquire. To put it another way, plans to acquire are 5.0% when calculated on the same demographic pattern that led to the 5.2% shown in the study published in the February 1982 issue of this magazine.

Not all instrument categories show a decrease in plans to acquire; 6 are up from last year, 2 equal, and 25 down. For present use, 13 categories are up, 2 equal, and 18 down. Largest gains in present use are 2.9 points for x-y plotting recorders, which rose from 35.6% to 38.5%, followed by 2.8 points for optical microscopes, 2.3 points for electrophoresis apparatus, 1.5 points for liquid chromatographs, 1.4 points for analytical balances, and 1.1 points for inductively coupled plasma spectrometers.

The largest declines in present use are 3.6 points for gas chromatographs, 2.6 points for strip-chart recorders, 2.3 points for laboratory furnaces and ovens, and 2.1 points for microchemical apparatus.

No category increased as much as 1 point in plans to acquire. The largest increase was 0.6 point for inductively coupled plasma spectrometers, with three categories tied for second at 0.5 point: UV/visible spectrophotometers, mass spectrometers,



and automated wet chemical analyzers. The only other categories to show increases were analytical balances at 0.3 point and NMR equipment at 0.1 point.

Plans to acquire equaled last year for particle size analyzers and DC plasma spectrometers. Largest losses in plans to acquire were strip-chart recorders at 2.4 points, and liquid chromatographs and fume hoods at 2.0 points.

Demographic data provided by readers responding to the Trendsurvey show that 20.2% are in engineering, 58.6% in physical science, 19.0% in life science or medicine, with 2.1% giving no discipline. Corresponding numbers last year were 22.1% engineering, 59.3% physical science, 15.4% life science or medicine, and 3.2% no answer to the discipline question.

By employer, 60.3% work in industry, 14.7% in universities, 15.8% in government, 3.1% in nonprofit organizations, 2.0% in medical research centers, 3.0% in other sectors, and 1.1% no answer. Corresponding data for 1982 were 66.2%, 12.2%, 13.0%, 2.8%, 1.2%, 2.4%, and 2.1%, respectively.

Average plans to acquire dropped from 4.6% to 4.1% for the engineering sector, from 5.5% to 4.9% for physical science, and from 4.8% to 4.1% for life science and medicine. By employer, plans to acquire in industry dropped from 5.2% to 4.7%, and from 5.1% to 4.4% in universities. In government, plans rose from 3.9% to 4.3%, while average plans also increased in nonprofits and medical research centers, from 3.7% to 4.3% and from 2.8% to 5.7%, respectively. Note, however, that these two sectors are represented by only 54 and 34 respondents.

By job function, 3.4% of respondents are corporate officers, 6.7% R&D executives, 13.7% project managers, 69.0% professional staff, 5.5% other titles, with 1.7% giving no answer. Corresponding data for last year were 2.8%, 6.5%, 16.1%, 68.4%, 4.7%, and 1.4%, respectively.

Geographic distribution once again parallels *IR&D* circulation, with 6.1% New England, 17.4% Middle Atlantic, 17.9% East North Central, 5.7% West North Central, 13.5% South Atlantic, 2.8% East South Central, 7.1% West South Central, 4.4% Mountain, 12.8% Pacific, and 11.8% giving no answer.

This Trendsurvey was conducted by including a prepaid business reply card in a mailing to *IR&D* readers in the United States in late September 1982. To meet deadlines, only replies received by November 8 could be included in this study. □

Growth rate (left) is calculated with present use as base for each instrument category. Total includes all those who plan to acquire; new users are those who do not presently use that particular instrument but who plan to acquire. Difference is present users planning to acquire additional or replacement instruments or equipment. Symbols indicate ties in rankings, with the category with the larger present use listed as the higher ranking.

PRESENT AND PLANNED USE —Data from 1,735 respondents	Use now					Plan to acquire within 1 year					Growth rate = plan to acquire ÷ present use				
	Total, 1,735		Engineering, 351	Physical science, 1,017	Life science or medicine, 330	Total, 1,735		Engineering, 351	Physical science, 1,017	Life science or medicine, 330	Total	Present users who plan to acquire		New users who plan to acquire	
	No.	%	No. %	No. %	No. %	No.	%	No. %	No. %	No. %	%	No.	%	No.	%
Analytical balances	1552	89.5	266 75.8	949 93.3	306 92.7	197	11.4	27 7.7	123 12.1	43 13.0	12.7	179	11.5	18	1.2
1982		88.1					11.1								
Analyzers, automated wet chem.	235	13.5	40 11.4	143 14.1	46 13.9	58	3.3	9 2.6	37 3.6	12 3.6	24.7	24	10.2	34	14.5
1982		14.3					2.8								
Analyzers, oxygen	260	15.0	61 17.4	149 14.7	39 11.8	33	1.9	10 2.8	17 1.7	4 1.2	12.7	14	5.4	19	7.3
1982		14.7					2.8								
Analyzers, particle size	292	16.8	78 22.2	169 16.6	39 11.8	69	4.0	19 5.4	40 3.9	9 2.7	23.6	23	7.9	46	15.8
1982		17.5					4.0								
Analyzers, polarographic	157	9.0	22 6.3	115 11.3	17 5.2	22	1.3	3 0.9	17 1.7	— —	14.0	4	2.5	18	11.5
1982		8.5					2.2								
Analyzers, thermal (DTA, TGA)	271	15.6	59 16.8	199 19.6	9 2.7	67	3.9	11 3.1	53 5.2	2 0.6	24.7	21	7.7	46	17.0
1982		15.7					4.0								
Baths, constant temperature	1066	61.4	159 45.3	637 62.6	251 76.1	90	5.2	21 6.0	44 4.3	23 7.0	8.4	57	5.3	33	3.1
1982		61.8					6.4								
Centrifuges	995	57.3	106 30.2	606 59.6	267 80.9	76	4.4	11 3.1	36 3.5	28 8.5	7.6	49	4.9	27	2.7
1982		57.3					4.6								
Chromatographs, gas	817	47.1	92 26.2	590 58.0	116 35.2	163	9.4	22 6.3	120 11.8	18 5.5	20.0	112	13.7	51	6.2
1982		50.7					10.6								
Chromatographs, liquid	593	34.2	48 13.7	397 39.0	136 41.2	183	10.5	13 3.7	129 12.7	37 11.2	30.9	101	17.0	82	13.8
1982		32.7					12.5								
Chromatographs, thin layer	369	21.3	17 4.8	229 22.5	112 33.9	31	1.8	2 0.6	19 1.9	10 3.0	8.4	16	4.3	15	4.1
1982		23.2					2.6								
Electrophoresis apparatus	211	12.2	15 4.3	70 6.9	123 37.3	36	2.1	3 0.9	13 1.3	19 5.8	17.1	14	6.6	22	10.4
1982		9.9					2.9								
Fume hoods	1414	81.5	239 68.1	883 86.8	264 80.0	134	7.7	29 8.3	81 8.0	20 6.1	9.5	101	7.1	33	2.3
1982		80.9					9.7								
Laboratory furnaces, ovens	1354	78.0	257 73.2	856 84.2	212 64.2	141	8.1	43 12.3	90 8.8	7 2.1	10.4	117	8.6	24	1.8
1982		80.3					9.3								
Microchemical apparatus	224	12.9	33 9.4	117 11.5	70 21.2	23	1.3	6 1.7	6 0.6	9 2.7	10.3	13	5.8	10	4.5
1982		15.0					2.1								
Microscopes, optical	1113	64.1	259 73.8	606 59.6	231 70.0	111	6.4	28 8.0	50 4.9	31 9.4	10.0	78	7.0	33	3.0
1982		61.3					6.7								
Microscopes, electron	302	17.4	79 22.5	165 16.2	49 14.8	54	3.1	19 5.4	21 2.1	12 3.6	17.9	14	4.6	40	13.2
1982		16.5					3.2								
NMR equipment	204	11.8	25 7.1	154 15.1	18 5.5	48	2.8	9 2.6	34 3.3	4 1.2	23.5	23	11.3	25	12.3
1982		11.9					2.7								
pH meters	1262	72.7	174 49.6	774 76.1	291 88.2	133	7.7	23 6.6	78 7.7	27 8.2	10.5	114	9.0	19	1.5
1982		72.7					8.5								
Recorders, strip-chart	1272	73.3	254 72.4	771 75.8	222 67.3	133	7.7	33 9.4	80 7.9	18 5.5	10.5	116	9.1	17	1.3
1982		75.9					10.1								
Recorders, X-Y plotting	668	38.5	185 52.7	393 38.6	75 22.7	116	6.7	36 10.3	61 6.0	17 5.2	17.4	57	8.5	59	8.8
1982		35.6					7.0								
Specific ion electrodes	575	33.1	78 22.2	404 39.7	86 26.1	136	7.8	18 5.1	91 8.9	24 7.3	23.7	77	13.4	59	10.3
1982		34.2					7.3								
Spectrometers, electron	59	3.4	15 4.3	38 3.7	6 1.8	14	0.8	5 1.4	5 0.5	4 1.2	23.7	3	5.1	11	18.6
1982		3.7					0.9								
Spectrometers, mass	250	14.4	49 14.0	169 16.6	25 7.6	55	3.2	12 3.4	35 3.4	7 2.1	22.0	19	7.6	36	14.4
1982		14.9					2.7								
Spectrometers, mass with GC	193	11.1	22 6.3	137 13.5	27 8.2	44	2.5	5 1.4	33 3.2	5 1.5	22.8	12	6.2	32	16.6
1982		12.2					3.3								
Spectrometers, plasma, dc	45	2.6	11 3.1	31 3.0	3 0.9	16	0.9	3 0.9	13 1.3	— —	35.6	3	6.7	13	28.9
1982		1.7					0.9								
Spectrometers, plasma, ICP	75	4.3	14 4.0	56 5.5	5 1.5	54	3.1	6 1.7	44 4.3	1 0.3	72.0	4	5.3	50	66.7
1982		3.2					2.5								
Spectrometers, x-ray	244	14.1	52 14.8	178 17.5	9 2.7	30	1.7	4 1.1	24 2.4	2 0.6	12.3	10	4.1	20	8.2
1982		13.8					2.5								
Spectrophotometers, atomic abs.	505	29.1	56 16.0	383 37.7	57 17.3	65	3.7	7 2.0	50 4.9	8 2.4	12.9	29	5.7	36	7.1
1982		30.0					4.9								
Spectrophotometers, fluorescence	261	15.0	32 9.1	144 14.2	76 23.0	38	2.2	8 2.3	16 1.6	12 3.6	14.6	11	4.2	27	10.3
1982		14.6					2.4								
Spectrophotometers, infrared	618	35.6	76 21.7	472 46.4	57 17.3	81	4.7	12 3.4	63 6.2	4 1.2	13.1	48	7.8	33	5.3
1982		37.0					5.6								
Spectrophotometers, UV/Vis	849	48.9	79 22.5	557 54.8	202 61.2	104	6.0	11 3.1	68 6.7	22 6.7	12.2	67	7.9	37	4.4
1982		49.5					5.5								
Titrators, automatic	316	18.2	41 11.7	224 22.0	46 13.9	81	4.7	11 3.1	58 5.7	11 3.3	25.6	27	8.5	54	17.1
1982		20.0					4.9								
Other	172	9.9	41 11.7	104 10.2	21 6.4	73	4.2	18 5.1	39 3.8	11 3.3	42.4	47	27.3	26	15.1
1982		9.0					3.7								

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INDUSTRIAL RESEARCH & DEVELOPMENT

MARCH 1983

3/28/83
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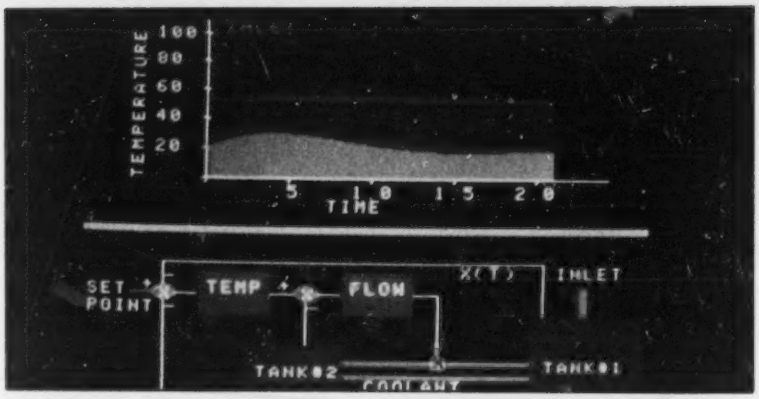
Clear up the picture of lab programs. See pp 110, 136.



INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $156.7-BILLION WORLDWIDE R&D INDUSTRY

EDITORIAL

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ABOUT THE COVER

More and more laboratories are using computerized systems to assemble data and to manipulate these data. Other computers automate equipment to relieve drudgery and to eliminate human error.

Another laboratory use for data-managing equipment is in the prediction of behavior for the assurance of quality in manufactured products.

In addition, laboratory managers often use computers to assemble data needed to predict what products or processes may be needed in the future, as well as to assess the future impact of currently active lab projects.

The input for such management problems also will include information on current markets, government regulations, and company history and image.

Articles on R&D management begin on pp 110 and 136. An article on planning a new laboratory begins on p 120.

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110 **Where will we find some new 'Edisons' for U.S. technology?** D.P. Laverty, marketing consultant, and E.A. Frand, Frand & Assoc.; we need to learn how to bring U.S. creativity to the forefront and obtain U.S. patents.
114 **Better motors from better designs using rare earth magnets:** P. Campbell, PA International Management Consultants; rare earth magnets perform better under dynamic conditions than either alnico or ferrite types.
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127 **Use an RF shield to prevent EMI from altering your results:** A. Zais, Keene Corp.; RF-shielded rooms help to protect electronic equipment from the ever-increasing amount of electromagnetic interference.
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136 **Be sure you say enough when you write your R&D proposals:** R.A.Golde, management consultant, and J.J. Schwartz, Boston Univ.; proposals should explain technical specifications and establish potentials for benefits.
141 **Tungsten barrier eliminates VLSI circuit shorts:** P.A. Gargini, Intel Corp.; one-step technique for selective deposition at aluminum-silicon interface eliminates circuit shorts caused by Al-Si interaction.

ERWIN FRAND'S THOUGHTS ON

PRODUCT DEVELOPMENT

Where have all the Edisons gone?

THE OTHER NIGHT, as my family and I sat eating a cold dinner by candlelight because somebody had knocked down a telephone pole and transformer a mile or so away, I began to realize how totally interdependent on one another we are these days. I then began to wonder, What physical act can a person carry on totally independent of the world around him? Finding an answer was a little bit more difficult than I thought. Even the simple act of drinking a glass of water is the culmination of the efforts of thousands. **There are literally hundreds of people involved in the business of manufacturing pipe, pumps, valves, chemicals, etc., to bring potable water to my kitchen faucet, and other hundreds who are involved in manufacturing, distributing, and marketing of glassware.**

I finally came to the conclusion that about the only thing an individual can do without some help from the rest of the world is to breathe. (The quality of the stuff that is available for breathing is beyond the scope of this article.) We have certainly come a long way from the Jeffersonian ideal of 200 years ago of being a nation of well-educated, independent farmers who were ready to serve their nation when necessary, but retire to their individual estates when not.

Since innovation and creativity are highly individual tasks, how then has this total interdependence affected the creativity of this country? Have we, in fact, by being so close to one another, lost something, or have things remained pretty much the same? While we are no longer as individualistic as we once were, perhaps we have compensated for that by having the thoughts, ideas, and expressions of others which can spark our own creativity impinged on us. Is there, then, any way we can measure what has happened to creativity and innovation of this country? **About the only long-term measure of innovation available is the number of patents issued each year.**

Now, admittedly, patents are not the best indicator of creativity and inventiveness, and there are many drawbacks to using that as an indication of creativity. The following list shows the number of patents issued to American citizens and companies per million population of the United States for the past 110 years. It does not include patents issued to foreign citizens or corporations.

1980—169	1920—349
1970—255	1910—382
1960—236	1900—324
1950—274	1890—402
1940—301	1880—258
1930—353	1870—287

The next list shows the number of patents issued to American citizens and corporations per million population in the decade from 1970 to 1980.

1980—169	1974—273
1979—171	1973—229
1978—215	1972—301
1977—217	1971—248
1976—234	1970—255
1975—231	

Whereas I have only picked the decade years, and most likely there are highs and lows between those chosen years, the data show that, with relatively few perturbations, the inventiveness of this country has been in a long, slow, but steady decline for almost a hundred years. The last two years, 1979 and 1980, show even a more precipitous falloff than previous years. **On a population basis, we are patenting less than half as many new ideas as we did 100 years ago.**

Not only are we patenting relatively fewer inventions, we are spending less in our attempts to do so. The next table shows the number of patents per billion dollars of gross national product in constant 1958 dollars from 1870 through 1970.

1970— 72	1910—293
1960— 87	1900—320
1950—117	1890—477
1940—175	1880—307
1930—236	1870—499
1920—256	

And the final table shows the numbers of patents per billion dollars of gross national product for the past decade, expressed in constant 1972 dollars (all data from U.S. Dept. of Commerce). It appears that for all of our wealth, we are getting less than a fourth as many inventions now as we did a century ago.

1980—25.8	1975—41.2
1979—26.3	1974—47.5
1978—33.9	1973—38.9
1977—35.1	1972—53.7
1976—39.5	

While there are fewer and fewer things to be invented because, by definition, one cannot reinvent the wheel, new technological breakthroughs usually beget other technological breakthroughs. This is borne out by the fact that the number of patents issued generally increases year to year on a numerical basis. However, we seem to be losing our touch, particularly in relation to the number of patents issued to foreigners and foreign corporations. **If we believe that innovation is the key to our continuing domination or success in world businesses, then we certainly need to get our act together and start turning out a few more Edisons in this country.**

Erwin A. Frand

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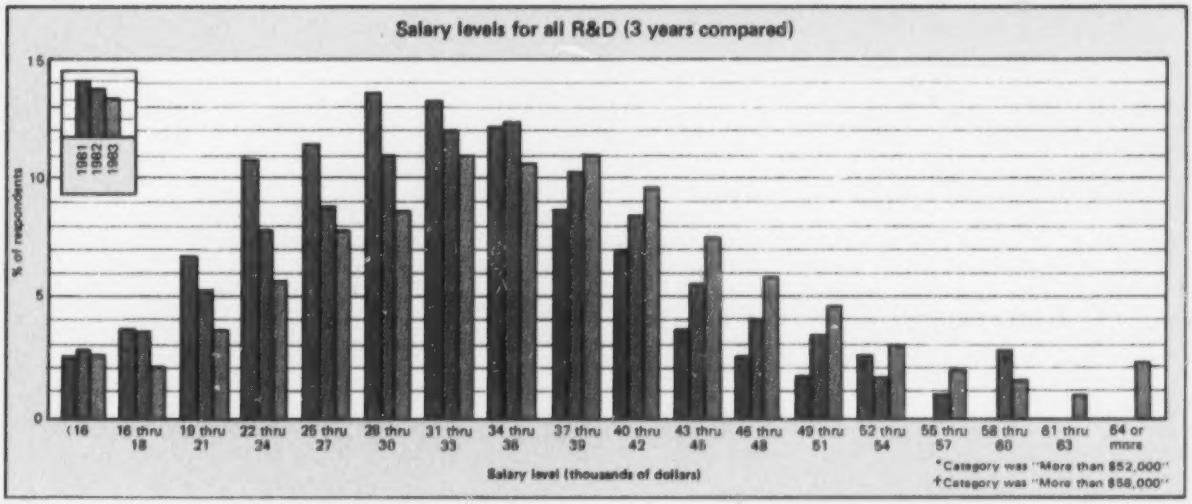
Robert R. Jones
Editor

Salary gains in R&D continue, but at a reduced rate



Impact of recession can be seen, but general trend is upward, and most workers at least did not lose buying power.

SALARIES ARE UP this year for workers in R&D and quality assurance, as they have been for a number of recent years, but the increases are smaller than in recent years, and some of the gains did not keep up with inflation.

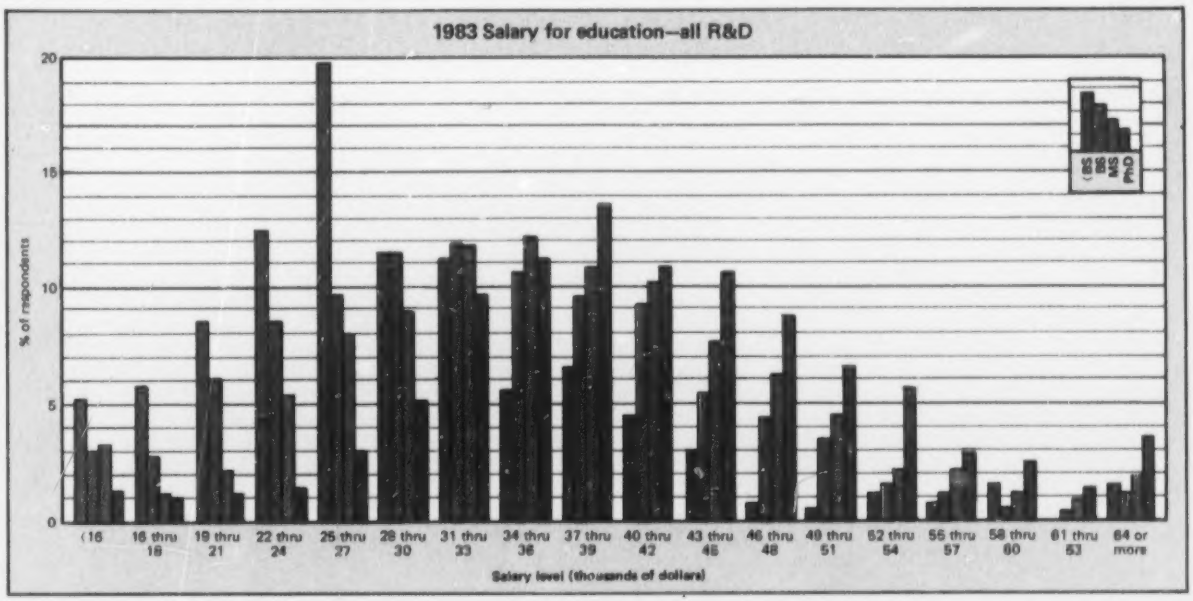
It is true this year, as it was a year ago, that the salary framework has shifted upward, if the more than 3,500 respondents to our survey are representative of the industry. This increase is demonstrated by our chart which shows "Salary levels for all R&D, three years compared." The chart reveals a new upper end for this survey—$64,000 per year or more—and it is well occupied without much reduction in percentages occupying the less-than-$16,000/year end. That the range of salaries paid to workers in R&D is increasing rapidly also is borne out by the fact that just three years ago 4% of our respondents said their salary was $46,000 a year or more. The most-populous single category at that time was the $25,000 through $27,000 per year range.

Last year, 12.5% reported earning $46,000 or more, including 2.8% who had salaries of $58,000 per year or more. The most-populous single category last year was the $34,000 through $36,000 range.

This year, 19.6% are earning $46,000 per year or more, and 2.1% report salaries of $64,000 or more, contributing to the more than $18 billion in annual salaries paid by the industry.

In these years, while the upper end of the R&D salary range has moved upward, the percent of respondents earning less than $16,000 has remained near 2.7%.

The median income for R&D workers, however, continues to rise. Having gone up



7.8% in 1981 and 7.7% last year, it stands at $36,260.

A third (33.4%) of this year's respondents received pay increases of 10% or more during the past year. Last year the figure was 47.3%, and the year before that it was 40.7%, so we have a sharp drop from what had been a trend toward larger salary increases. This can be seen in the following table:

Increases in salary, all levels R&D

	% of respondents			
Amount	1983	1982	1981	1980
None	14.7	6.3	5.2	5.7
Less than 2%	1.9	1.2	0.9	1.5
2 thru 5%	15.9	10.6	8.0	12.4
6 thru 9%	34.2	34.5	45.2	52.0
10 thru 13%	25.1	34.0	29.7	19.6
14% or more	8.3	13.3	11.0	8.8
Ahead of inflation	33.4	47.3	40.7	28.4

Perhaps most significant is the fact that the number receiving no raise has more than doubled since a year earlier.

The best record for increases this year was reported by ceramists, the discipline which led last year's raise chart when more than 90% of the ceramists among our respondents received salary increases of 6% or more.

In this year's survey, 83.3% of the ceramists reported increases of 6% or more. Next highest was chemical engineers with 73.8% doing that well. These details and those of five other parameters are displayed in charts for 12 disciplines on the accompanying pages. The charts present a unique opportunity for comparisons of age, experience, salary, etc., between the disciplines.

Looking at median salaries by disciplines, metallurgists, with 1.8% median salary gain for the past year, fell from second to sixth place in the rankings. At the same time, chemical engineers, with a 10.1% median salary gain, did the reverse, moving from sixth to second.

Rankings for disciplines by median salary

Rank			Median salary		
1983	1982	Discipline	1983	1982	% increase
1	1	Aero. Engr.	$41,150	$38,240	7.6
2	6	Chem. Engr.	38,890	35,340	10.1
3	3	Physicist	38,500	37,070	3.8
4	4	Mathematician	38,450	36,950	4.1
5	5	Ceramist	38,400	35,950	6.8
6	2	Metallurgist	38,333	37,670	1.8
7	8	Mech. Engr.	38,100	34,990	8.9
8	7	Elec. Engr.	37,480	35,250	6.3
9	9	Geologist	36,950	33,950	8.9
10	10	Chemist	34,888	32,190	8.4
11	11	Biologist	34,380	30,950	11.1
12	12	Other	32,450	30,670	5.8
13	13	Indust. Engr.	30,520	29,950	1.9

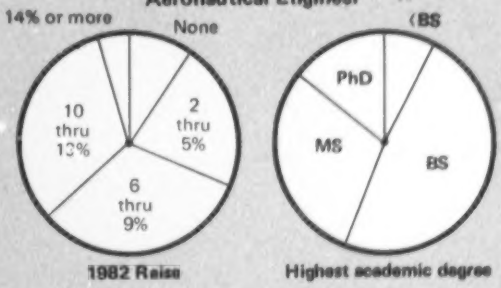
As was true last year, several features about this year's survey results suggest that age, experience, and advanced degrees have been more-than-usually important factors in hiring and in job tenure recently. That seems to be consistent with the economic situation and may be one possible explanation for an increase in the percentage of respondents with PhD degrees. The percentage has moved from 27.6 in 1980 through 29.4 in 1981 and 30.2 in 1982, to 32.3% in this survey.

Biologists continue to lead the disciplines in the percentage having a PhD, at 62.7% this year, up from 58.6%. Physicists, at 50.1% PhD, are up from 47.8%, but have been passed by ceramists at 53.7%. These are followed by geologists, 44.7%; chemists, 39.3%; and metallurgists, 35.3%.

Industrial engineers have the lowest percentage of respondents with a PhD degree at 8.6%, but that is up from 6.5% just a year ago.

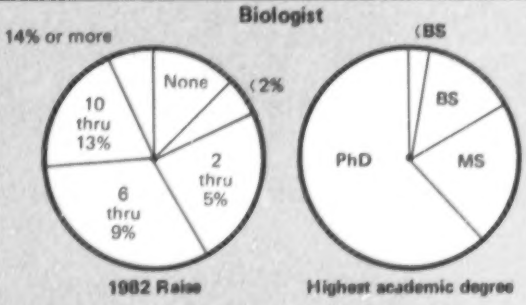
When master degrees and doctorates are considered together and the disciplines

Aeronautical Engineer



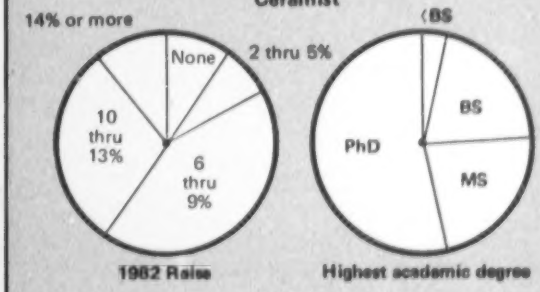
1982 salary range:	<$22,000 = none >$58,000 = none	**Median** $41,150
Years with present employer:	< 1 yr = 7.3% >36 yrs = 2.4%	**Median** 10.7 yrs
Age of respondents:	<26 yrs = 2.5% >65 yrs = none	**Median** 45.5 yrs
Years of experience:	< 1 yr = none >40 yrs = none	**Median** 21.67 yrs

Biologist



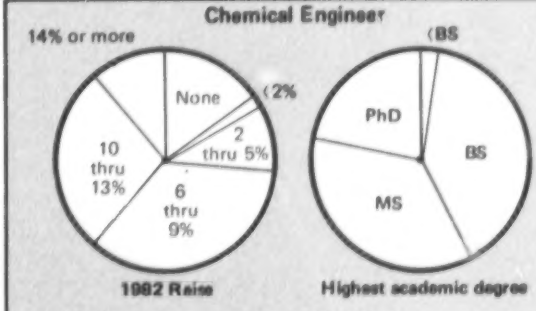
1982 salary range:	<$16,000 = 3.8% >$64,000 = 1.1%	**Median** $34,380
Years with present employer:	< 1 yr = 4.9% >33 yrs = none	**Median** 9.62 yrs
Age of respondents:	<26 yrs = 1.6% >65 yrs = none	**Median** 41.18 yrs
Years of experience:	< 1 yr = none >35 yrs = none	**Median** 13.3 yrs

Ceramist



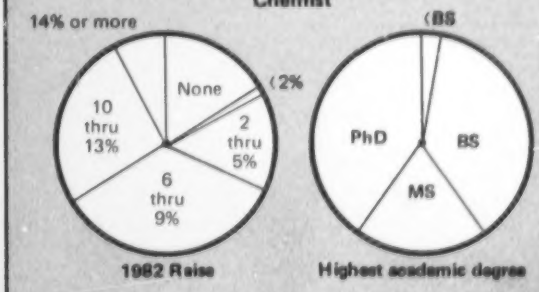
1982 salary range:	<$16,000 = 1.9% >$64,000 = 1.9%	**Median** $38,450
Years with present employer:	< 1 yr = 1.9% >30 yrs = none	**Median** 8.15 yrs
Age of respondents:	<26 yrs = 5.6% >60 yrs = none	**Median** 37.38 yrs
Years of experience:	< 1 yr = 1.9% >35 yrs = none	**Median** 11.52 yrs

Chemical Engineer



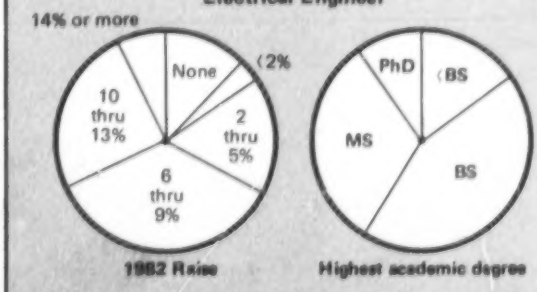
1982 salary range:	<$16,000 = 2.2% >$64,000 = 3.2%	**Median** $38,890
Years with present employer:	< 1 yr = 4.3% >36 yrs = 1.8%	**Median** 9.37 yrs
Age of respondents:	<26 yrs = 5.4% >65 yrs = 1.8%	**Median** 42.17 yrs
Years of experience:	< 1 yr = 1.1% >40 yrs = 2.2%	**Median** 17.42 yrs

Chemist



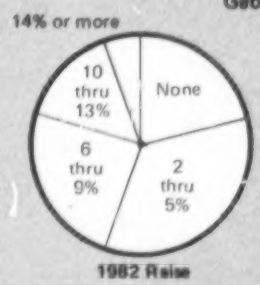
1982 salary range:	<$16,000 = 1.9% >$64,000 = 0.7%	**Median** $34,880
Years with present employer:	< 1 yr = 3.8% >36 yrs = 0.9%	**Median** 9.53 yrs
Age of respondents:	<26 yrs = 3.3% >65 yrs = 0.4%	**Median** 40.29 yrs
Years of experience:	< 1 yr = 1.2% >40 yrs = 1.1%	**Median** 14.05 yrs

Electrical Engineer

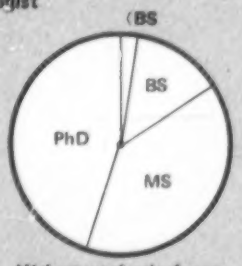


1982 salary range:	<$16,000 = 3.0% >$64,000 = 2.7%	**Median** $37,480
Years with present employer:	< 1 yr = 4.3% >36 yrs = 0.8%	**Median** 11.15 yrs
Age of respondents:	<26 yrs = 1.9% >65 yrs = 1.4%	**Median** 44.79 yrs
Years of experience:	< 1 yr = 1.1% >40 yrs = 2.2%	**Median** 19.2 yrs

Geologist



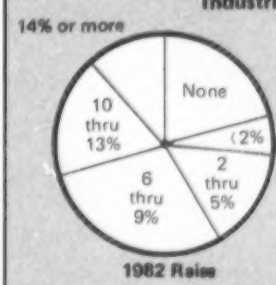
1982 Raise



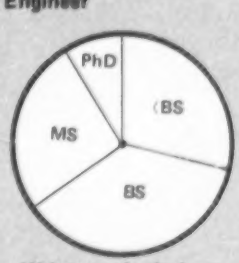
Highest academic degree

1982 salary range:	⟨$16,000 = 5.3% ⟩$64,000 = 7.9%	**Median** $36,950
Years with present employer:	⟨ 1 yr = 2.6% ⟩36 yrs = none	**Median** 6.95 yrs
Age of respondents:	⟨26 yrs = none ⟩65 yrs = 6.3%	**Median** 39.14 yrs
Years of experience:	⟨ 1 yr = none ⟩40 yrs = 2.6%	**Median** 13.23 yrs

Industrial Engineer



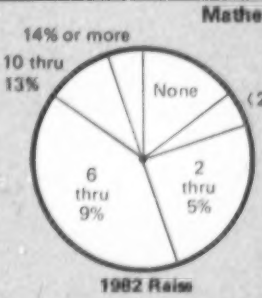
1982 Raise



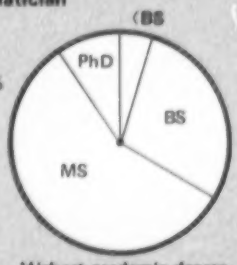
Highest academic degree

1982 salary range:	⟨$16,000 = 6.3% ⟩$64,000 = 6.3%	**Median** $30,520
Years with present employer:	⟨ 1 yr = 5.7% ⟩33 yrs = none	**Median** 10.95 yrs
Age of respondents:	⟨26 yrs = none ⟩65 yrs = 8.8%	**Median** 40.5 yrs
Years of experience:	⟨ 1 yr = 2.9% ⟩40 yrs = 11.8%	**Median** 14.6 yrs

Mathematician



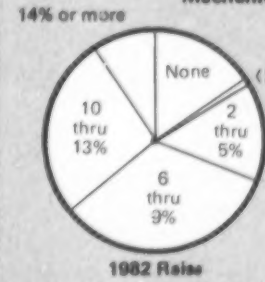
1982 Raise



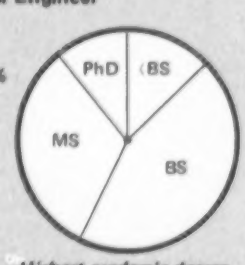
Highest academic degree

1982 salary range:	⟨$16,000 = 4.8% ⟩$64,000 = none	**Median** $38,450
Years with present employer:	⟨ 1 yr = none ⟩36 yrs = 4.8%	**Median** 12.95 yrs
Age of respondents:	⟨31 yrs = none ⟩65 yrs = 4.8%	**Median** 50.5 yrs
Years of experience:	⟨ 5 yrs = none ⟩40 yrs = 4.8%	**Median** 24.6 yrs

Mechanical Engineer



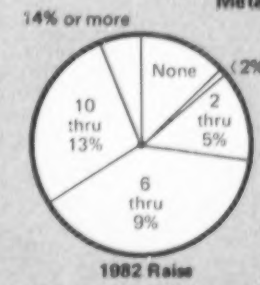
1982 Raise



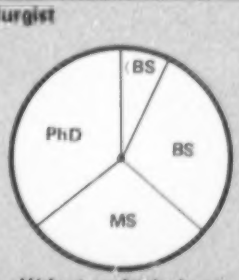
Highest academic degree

1982 salary range:	⟨$16,000 = 3.5% ⟩$64,000 = 2.6%	**Median** $38,100
Years with present employer:	⟨ 1 yr = 7.1% ⟩36 yrs = 0.6%	**Median** 10.95 yrs
Age of respondents:	⟨26 yrs = 4.1% ⟩65 yrs = 1.9%	**Median** 44.02 yrs
Years of experience:	⟨ 1 yr = 1.0% ⟩40 yrs = 2.6%	**Median** 18.64 yrs

Metallurgist



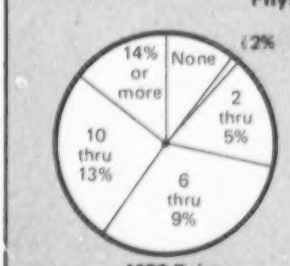
1982 Raise



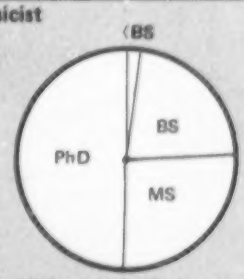
Highest academic degree

1982 salary range:	⟨$16,000 = 2.2% ⟩$64,000 = 4.9%	**Median** $38,330
Years with present employer:	⟨ 1 yr = 5.4% ⟩36 yrs = 1.1%	**Median** 7.34 yrs
Age of respondents:	⟨26 yrs = 4.3% ⟩65 yrs = 0.5%	**Median** 39.72 yrs
Years of experience:	⟨ 1 yr = 1.6% ⟩40 yrs = 1.1%	**Median** 13.04 yrs

Physicist

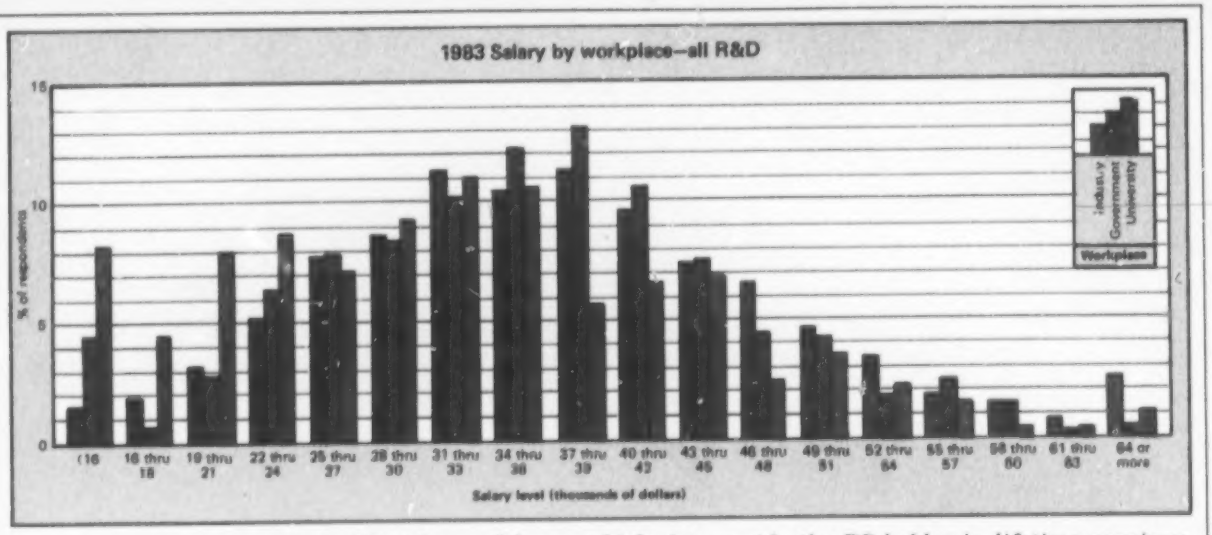


1982 Raise



Highest academic degree

1982 salary range:	⟨$16,000 = 2.3% ⟩$64,000 = 3.1%	**Median** $38,450
Years with present employer:	⟨ 1 yr = 7.0% ⟩36 yrs = 0.3%	**Median** 9.22 yrs
Age of respondents:	⟨26 yrs = 2.0% ⟩65 yrs = 1.1%	**Median** 42.43 yrs
Years of experience:	⟨ 1 yr = 0.8% ⟩40 yrs = 1.1%	**Median** 16.17 yrs



are ranked for advanced degrees, biologists and geologists tie with 84%. Ceramists and physicists are tied at 75%, and mathematicians and metallurgists are close at 66.6 and 63.6%. Of the nearly 3,500 respondents this year, 57.6% have at least one advanced degree, up from 53.9% last year.

The value of an advanced degree is reflected in many ways. In dollar and cents terms, the advantages of having an advanced degree vary across the disciplines. For our respondents as a whole, median salaries by highest academic degree are compared in the table:

Salaries compared by academic degrees

Degree	Median salary 1983	Median salary 1982	Percent change	Annual difference 1983	Annual difference 1982	Difference increase %*
Doctorates	$40,590	$38,520	+ 5.4	$4,310	$4,510	− 4.4
Masters	36,280	34,010	+ 6.7	3,100	2,750	+12.7
Bachelors	33,180	31,260	+ 6.1	5,100	6,490	−21.4
<Bachelors	27,670	24,770	+11.7			

*Difference above next-lower degree

The income advantages of baccalaureate and advanced degrees are increasing faster than inflation. The advantage in annual income for a PhD over less-than-bachelor this year is $12,920, down 6% from last year, but still well above the $9,994 spread of two years ago. Advantage of PhD over bachelor is $7,410 this year compared to $7,260 last year and $6,148 in 1981.

We can expect the holder of a PhD to work approximately 25 years after getting that degree, as our survey shows, with the possibility of a 30-year career for the person who enters the work force after obtaining a BS. Assuming that a 10% interest rate prevails over this 25-year career, and making allowances of $300,000 for tuition, missed earnings, etc., for an adjustment from the gross salary difference, the PhD still would—as reported a year ago—realize an advantage over the BS of more than $475,000.

The researcher with an MS would outdo the BS holder in lifetime earnings, when appropriately reduced for tuition, a later career start, etc., by nearly $200,000.

The most impressive change in the return for advanced education comparisons is with the persons with less than a BS degree. Their median income increased by 11.7% last year. Unfortunately, this may be only a reflection of the job prospects for such education and not an across-the-board improvement. However, this did cause the 25-year career advantage for a PhD over less than a BS to drop below $1 million for the first in several years.

Presentation of these figures should not leave the impression that we think the only advantage to advanced degrees is more income. However, the difference in income is the only such advantage that can be derived from this survey.

The annual income advantage for a PhD over an MS has increased steadily from 1978 when it was $2,000, hitting $3,300, $3,876, and $4,043 before last year's $4,510. This year's figure dropped off slightly to $4,310.

As might be expected, the PhDs tend to be clustered in the upper salary ranges, as shown by this table:

Distribution of degrees for all respondents and in selected salary ranges

Category	<BS	BS	MS	PhD
All R&D	7.7%	34.7%	25.3%	32.3%
$22,000 thru $24,999	16.8	51.5	23.3	8.4
$56,000 thru $60,999	8.2	14.3	20.4	57.1
$61,000 thru $63,999	0.0	14.8	29.6	55.6
$64,000 or more	5.4	18.9	23.0	52.7

We would expect the percentages of degrees to be the same or to vary randomly in each degree column across the salary ranges if academic accomplishment were not a salary factor.

In the second part of this salary report we will present the salary picture as provided by the same more than 3,500 respondents when broken into categories of experience and workplace. □

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Chromatography developments and applications
- columns
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A hole in the theory of relativity?

Exothermic production of nitrides

News of importance to people in R&D

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Relativity relatively irrelevant? See p 95.

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SERVING THE $156.7-BILLION WORLDWIDE R&D INDUSTRY

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ABOUT THE COVER

Until recently, the preparation of refractory nitrides has been a slow process requiring the use of high temperatures and pressures. In the usual processes, yields have been low.

A new process, developed by researchers at Lawrence Livermore National Laboratory, takes advantage of exothermic reactions to obtain yields as high as 100% of theoretical.

Powdered titanium, hafnium, or zirconium is mixed with a solid source of nitrogen, then ignited. A reaction front moves rapidly through the compacted mass. The temperature rises as heat is evolved, removing the need for supplying large amounts of heat externally.

The refractory products are used for abrasive paper, grinding wheels, jewelry coatings, electronics parts, and high-temperature crucibles.

A related article begins on p 88.

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122 **Precise controller assures quality for ceramics production:** Larry Rook, Joslyn Mfg. & Supply Co., and Richard I. Gruber, Honeywell Inc.; digital control programer permits ready variation of programs to gain full advantage of ceramics used in electrical surge arresters.
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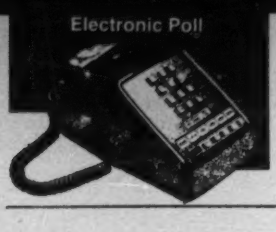


OPINION POLL RESULTS

Readers oppose MX missiles; favor our Electronic Poll

SCIENTISTS and engineers in research, development, and quality assurance are opposed to funding the MX missile program, 56% to 37%. This is true if the nearly 2,000 respondents to our Electronic Poll are typical of their industry.

And respondents liked the Electronic Poll. Some 77% said they liked it more than our conventional polls in which they marked their responses on Reader Service Cards. Nine percent like it less than the cards. In any case, 1,990 readers had dialed in usable responses in the barely three weeks that we kept the WATS lines open for that purpose. Thus, you have this sampling of reader opinion four months sooner than if we had used the cards.

How about the quality of the survey? As a check on quality, we asked some questions that had been asked before. We rate the correlation between then and now as high. You can judge for yourself. Here are two examples: For question B, the answers in the Electronic Poll were 73%, 25%, 2%. Earlier (1978), using Reader Service Cards, results were 74%, 24%, 2%. Answers to question M were 50%, 39%, 11% in the Electronic Poll; 52%, 35%, 13% in the earlier survey.

Perhaps the most disappointing response in the survey came to the question, "Have you ever written to your congressman about disarmament?" Nearly three out of four never have, and only one in ten have done so recently. This is unchanged from four years ago, and is a bit of a contradiction, since 71% of the respondents believe that such an effort might help world peace.

On the positive side, one out of three respondents study disarmament issues regularly, up from one in four, earlier.

Results of the Electronic Poll follow:

A. Weisskopf said, "The reduction and eventual abolition of nuclear weapons must have absolute priority." Do you agree with him?
1. Agree . 61% 2. Disagree . . 37% 3. No opinion . 2%

B. He added, "The consequences of nuclear war are irreparable . . ." Do you agree?
1. Agree . 73% 2. Disagree . 25% 3. No opinion 2%

C. And then, ". . . the consequences of other setbacks in world politics can be corrected." Do you agree?
1. Agree . 60% 2. Disagree . . . 29% 3. No opinion . 11%

D. Do you study disarmament issues?
1. Regularly 33% 2. Occasionally 61% 3. No 6%

E. Have you ever written to your congressman about disarmament?
1. Recently . 10% 2. Not recently 19% 3. No. 71%

F. Do you think that it helps or might help world peace when people write to Congress on this subject?
1. A lot . . . . . 14% 2. A little . . . 57% 3. No. 29%

G. Do you favor a nuclear weapons freeze using currently available safeguards?
1. Yes . . . . . 47% 2. No . . . . . 47% 3. No opinion 6%

H. Do you believe there should be funding for an MX missile production program?
1. Yes . . . . . 37% 2. No . . . . . 56% 3. No opinion . 7%

I. Does the MX "dense pack" plan make sense to you?
1. Yes . . . . . 13% 2. No . . . . . 76% 3. No opinion 11%

J. Do you favor banning all nuclear weapons tests?
1. Yes . . . . . 51% 2. No . . . . . 45% 3. No opinion . 4%

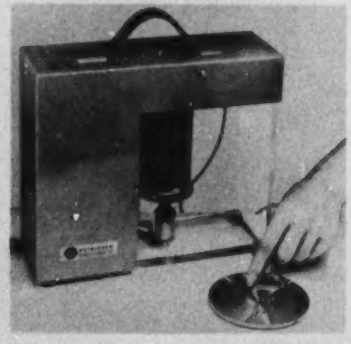
K. Do you favor curtailing international arms tranfers?
1. Yes . . . . . 70% 2. No . . . . . 23% 3. No opinion . 7%

L. Do you favor worldwide reduction in military expenditures that is . . .
1. Substantial . 63% 2. Moderate . 30% 3. Not at all 7%

M. Would you favor establishment of a transnational peace-keeping force in the next 10 years?
1. Yes . . . . . 50% 2. No . . . . . 39% 3. No opinion 11%

N. Considering this (telephone) method for you to respond to our Opinion Poll Questionnaire, would you say that—in comparison to the mail-in cards—you like the telephone response . . .
1. More. . . . . 77% 2. Not as much 9%
3. No opinion or about the same 14

safe, efficient retrieval of spilled mercury . . . with Bethlehem Hg VACUPICK



This latest development from Bethlehem is a convenient, simplified way to retrieve spilled mercury droplets or larger pools of mercury. It operates by means of an oilless vacuum pump capable of 20" Hg. A 40" soft plastic tube with stainless steel pick retrieves the spilled mercury and deposits it in a plastic receiving bottle. A rubber ball shut-off valve prevents mercury from being sucked into the pump. There is no detectable mercury vapor from pump exhaust, and the unit complies with OSHA requirements. See your laboratory dealer for details on this efficient way to salvage spilled mercury. Or write or call Bethlehem for complete information.

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Current laboratory design is good but not great

Research data management tools will speed your work

Women's salaries in R&D move up despite recession

Unique news section for people in R&D

but no Lab of the Year. See p 103

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ABOUT THE COVER

Impatt (impact avalanche travel-time) diodes convert direct current to microwave signals for use in communications equipment, high-speed data links, and remote sensing devices. The diodes were made by vapor phase epitaxy in an InGaAs-InP semiconductor material fabrication system at Research Triangle Institute, Research Triangle Park, NC.

The gold spokes, used to connect the devices to testing systems, are each approximately 1,000-μm long. To produce practical Impatt diodes using InGaAs and InP will require engineers to make several advances, particularly in the avalanche and drift regions of the diodes.

Diodes were photographed for *IR&D* by Cliff Haac of the Research Triangle Institute.

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Robert R. Jones
Editor

While R&D salary gains are down, women fared better than men in '82

Impact of recession is obvious for all, but bright spots show up throughout responses to IR&D's annual survey.

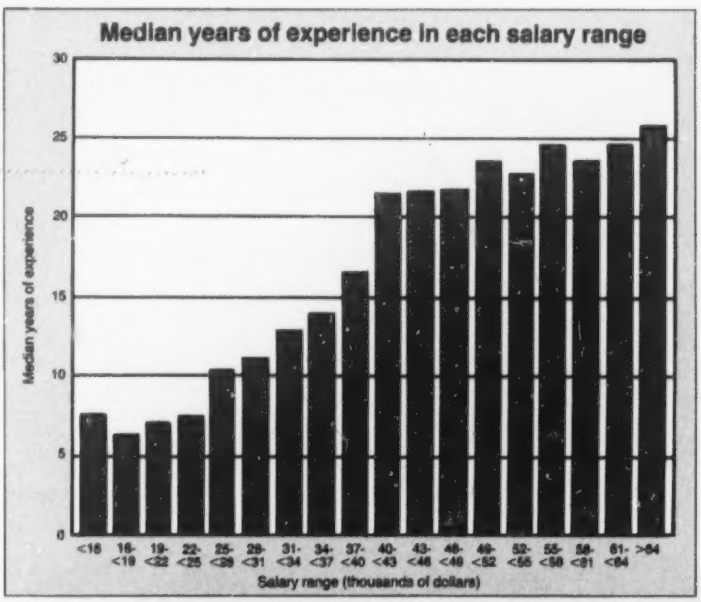
WOMEN who work in research, development, and quality assurance did well in terms of substantial salary increases (14% or more) during the past year. And they did better than men did; but neither sex did as well this year as last if results of our most recent survey of R&D salaries are representative of the industry.

While women dominated the low end of the salary increase scale in last year's report (12.5% getting less than a 2% increase, *vs* 6.5% of the men getting less than 2%), this year showed little change for the women and a lot of change for the men.

In our most recent survey, 14% of the women reported that they had received less than 2% salary increase last year, while 16.7% of the men were in that category. The portion of women at the low end increased by 12%, while the portion of men soared by

Salary increases by sex

	1982		1981	
Amount	Male %	Female %	Male %	Female %
None	14.8	12.9	5.4	11.8
Less than 2%	1.9	1.1	1.1	0.7
2 thru 5%	15.8	17.7	10.7	8.2
6 thru 9%	34.2	33.4	35.4	26.4
10 thru 13%	25.2	23.1	34.4	33.3
14% or more	8.1	11.8	13.0	19.6



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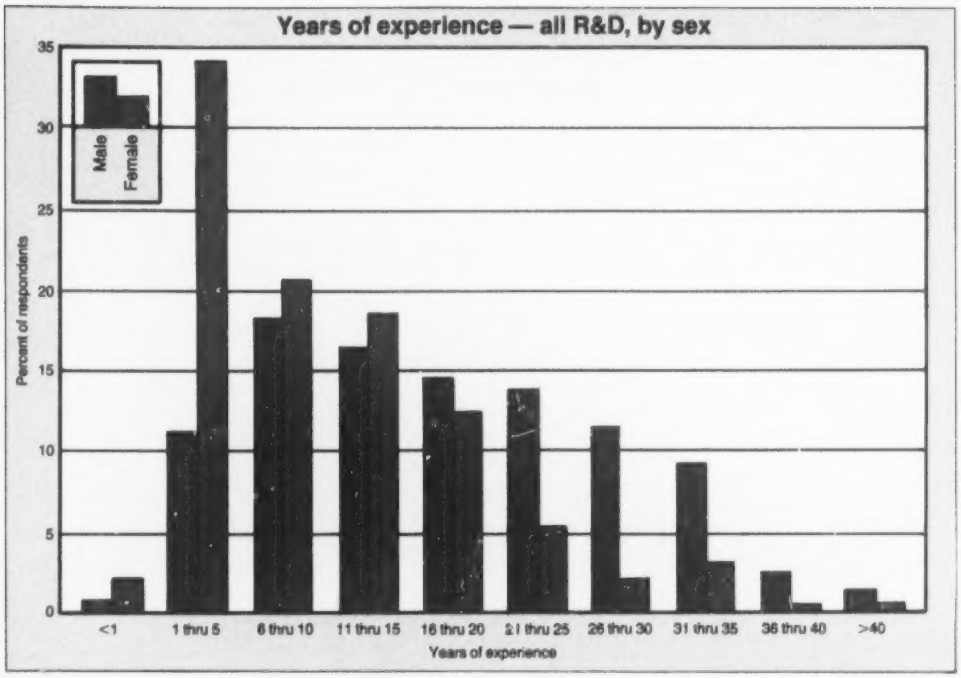


157%, passing the percentage of women in the low-end category.

If we assume that inflation last year averaged 9%, then more than a third of the women respondents (34.9%) received salary increases that more than made up for the reduced buying power of inflation.

On that same basis, one woman in nine (11.8%) received buying power increases of at least 5%. Only one man in 12 did that well last year.

Nearly 35% of women respondents (34.9%) are earning $31,000 per year or more, up from 25% last year and 22% the year earlier. For the men, 71.3% are earning more than $31,000 per year, up from 63% last year.

At the top end, 3.1% of the women respondents are earning $55,000 per year or more, while just over twice that percentage of the men are in that upper grouping.

Any comparisons of salaries for women are incomplete without consideration of such factors as education, experience, and time with present employer. Women in R&D simply do not have the advantages that men have in these categories. Whatever may be the reasons for them, these are the facts of the situation, and they help to explain important salary differences.

You will see from the chart that women working in R&D have far less experience than their male counterparts. Median years of experience for males in R&D is 16.37, changed only slightly from the two previous years. For women, it is 8.23 years, up from 7.36 in 1982 and in line with 1980 and 1981.

Workers with more than 20 years' experience make up 38.5% of the male respondents, virtually unchanged from the past two years, and 11.6% of the female respondents, down from 12.1% last year and down sharply from near 16% in 1980 and 1981.

For many understandable reasons, women do not have the opportunities to build up a backlog of experience. Not only do we have young women entering the job market, we also have older women who are returning to work after rearing a family or who are starting a second career. Whatever the reasons may be, we find that 36.3% of the female respondents have less than six years' experience, compared to 12.0% of the men in that category.

Both of these figures are down from last year's 39.9% and 13.6%, suggesting that the recession's impact is reflected in dismissals at the low end or reduced hiring of inexperienced workers.

We have seen in this study over the years that experience is rewarded in the paycheck, and a large portion of the women working in R&D simply are not in the experience ranges where pay is the highest.

For reasons mentioned above, there are few women with 20 years' experience in this field. And there is another reason. In this year's group of respondents, 70.6% of the women are 40 years of age or younger, down from 77.2% in that age group last year. Only 46.2% of the men (the same as last year) are in that young an age group.

The same sort of situation applies to education. The big money goes to the higher degrees. This year, the advantage of a PhD over a bachelor degree works out to be $7,410 per year—projectable to some $475,000 over a 30-year career. We went into this in detail in the March issue.

This sort of difference comes down hard on women who have not had the opportunity to obtain advanced degrees. The percentage of women in this year's respondents who have a PhD is up from the two previous years. Still, the women's percentage at 21.4 is substantially lower than the men's 33.0

(which is up from 31.5 last year and 30.3 two years ago).

Nothing helps a person move up the corporate ladder like being with the same organization for a long time. Men in R&D have that opportunity, being in fact a notably stable group.

One percent of our male respondents report being with their present employers for more than 36 years. Including those, 3.8% of the males have been with their present employers for more than 30 years. None of the female respondents have been with their present employer for more than 36 years, and only 1.0% have exceeded 30.

Women with fewer than 7 years in the same firm make up 57.5% of the female respondents, in line with the past two years. Women with 7 through 9 years in the same firm make up 15.1% of the female respondents, compared to 12.5% last year. For men, only 38.6% have been with their present firm less than 7 years, with another 12.3% in the 7 through 9 category.

Much additional information about the people who work in research, development, and quality assurance is provided in the accompanying charts and tables.

Following are the complete results of the Opinion Poll Survey:

1983 IR&D Salary Survey Results

	All R&D	Male R&D	Female R&D
1. What is your annual salary (thousands)?			
Less than $16	2.7	2.4	7.0
$16 thru $18	2.0	1.6	9.7
$19 thru $21	3.7	3.4	9.1
$22 thru $24	5.7	5.2	15.1
$25 thru $27	7.8	7.6	13.4
$28 thru $30	8.7	8.6	10.8
$31 thru $33	11.0	11.0	12.4
$34 thru $36	10.7	11.1	5.9
$37 thru $39	11.0	11.4	4.3
$40 thru $42	9.6	9.9	3.8
$43 thru $45	7.4	7.7	2.7
$46 thru $48	5.9	6.0	2.7
$49 thru $51	4.5	4.7	—
$52 thru $54	3.0	3.2	—
$55 thru $57	1.9	1.9	1.6
$58 thru $60	1.4	1.4	0.5
$61 thru $63	0.8	0.8	0.5
$64 or more	2.1	2.2	0.5
2. Your raise during the past year was . . .			
None	14.7	14.8	12.9
Less than 2%	1.9	1.9	1.1
2 thru 5%	15.9	15.8	17.7
6 thru 9%	34.2	34.2	33.3
10 thru 13%	25.1	25.2	23.1
14% or more	8.3	8.1	11.8
3. How long have you worked for your present employer?			
Less than one year	4.7	4.6	5.9
1 thru 3 years	18.8	18.0	33.3
4 thru 6 years	16.2	16.0	18.3
7 thru 9 years	12.4	12.3	15.1
10 thru 12 years	8.3	8.6	4.8
13 thru 15 years	8.7	8.6	9.1
16 thru 18 years	8.3	8.5	4.8
19 thru 21 years	6.7	6.8	4.3
22 thru 24 years	4.4	4.6	1.1
25 thru 27 years	4.8	4.9	1.1
28 thru 30 years	3.1	3.3	1.1
31 thru 33 years	2.2	2.3	0.5
34 thru 36 years	0.6	0.7	0.5
More than 36 years	0.8	0.8	—
4. What is your age?			
Under 26	3.3	2.7	13.9
26 thru 30	10.5	9.6	27.3
31 thru 35	16.8	16.7	17.6
36 thru 40	16.8	17.2	11.8
41 thru 45	15.4	15.5	13.9
46 thru 50	11.6	12.0	5.3
51 thru 55	12.7	13.1	3.7
56 thru 60	8.3	8.4	5.9
61 thru 65	3.6	3.8	—
Over 65	1.0	1.0	0.5
5. How many years of experience do you have?			
Less than one year	1.0	0.9	2.1
1 thru 5 years	12.3	11.1	34.2
6 thru 10 years	18.5	18.3	20.9
11 thru 15 years	16.7	16.6	18.7
16 thru 20 years	14.3	14.4	12.3
21 thru 25 years	13.4	13.9	5.3
26 thru 30 years	11.1	11.5	2.1
31 thru 35 years	8.8	9.1	3.2
36 thru 40 years	2.5	2.6	0.5
More than 40 years	1.4	1.4	0.5
6. What is the highest degree you hold?			
Less than bachelor	7.7	7.7	5.9
Bachelor	34.7	34.1	46.0
Master	25.3	25.2	26.7
Doctor	32.2	33.0	21.4
7. What is your profession?			
Chemist	37.9	36.9	56.7
Chemical engr	7.8	8.2	2.1
Mechanical engr	8.9	9.1	3.2
Electrical engr	10.4	10.6	4.8
Aeronautical engr	1.2	1.2	—
Industrial engr	1.0	1.0	—
Physicist	10.0	10.3	5.3
Metallurgist	5.2	5.3	3.7
Biologist	5.2	5.0	9.1
Mathematician	0.6	0.6	—
Ceramist	1.5	1.6	1.1
Geologist	1.1	1.1	1.1
Other	9.1	9.0	12.8
8. Do you work in . . .			
Industry	74.0	74.2	70.1
Government	15.5	15.4	17.4
University	10.5	10.4	12.5

cost of R&D and the risks involved, no R&D director wants direct government support. That is, he or she wants no direct grants for industrial R&D.

Still, the tax credits for R&D, now part of the U.S. tax laws, are considered to be an acceptable form of government support for R&D. Other less direct supports also are accepted and appreciated. For example, the direct NASA and Dept. of Defense contracts are part of the industrial scene in the U.S. And work under these contracts often leads to industrial application of the knowledge learned.

In general, industry has no objections to working on such programs if the company doing the work can retain the rights to commercial practice of developments that can result in patents. The whole area of tax law touches this problem of government involvement in the innovation process.

Investment credits and depreciation schedules for plant and equipment obviously are key factors for executives to consider in judging whether a technology program is justifiable. If the tax laws and environmental regulations change frequently, the risks of making an expensive error during the innovation process become too great, and R&D efforts stop. As Dr. Sam Tinsley, director of corporate technology at Union Carbide, Danbury, CT, puts it, "U.S. industry only wants to be able to compete fairly with the rest of the world."

University support. On the other hand, during the past 20 years, government support has evolved as the mainstay of the research programs carried out at many U.S. universities. Most industrial R&D executives accept this approach as a proper role of government in supporting basic research. In this way, basic research can be aimed at some of the fundamental problems facing the people of the U.S.

No one can predict with certainty how such research might result in a particular field of application. Therefore, it is appropriate that this type of research be supported by the country as a whole.

We have noted earlier that industry can supplement this support in areas of particular interest to a given company or industry. But we might consider some of the recent cutbacks in the support of university R&D by the government as a possible detriment to future innovation in this country.

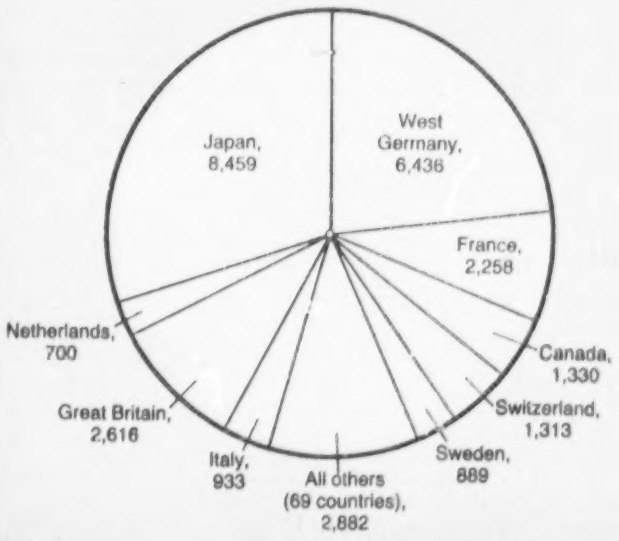
Friendly environment. Even though Hittinger and other R&D directors do not feel that government should support industry directly in its R&D efforts, they do feel that government should not be an adversary when industry tries to implement its innovative efforts.

Members of industry often express fear that government, through antitrust suits, product-liability suits, and OSHA and EPA regulations, can impede the innovative thrust that industry tries to make. There is an appreciation that some legislation in this area is proper and, in fact, needed, so that all members of an industry have to compete on an equal basis for the good of the general public.

Of course, there are differences of opinion between some people in industry and some advocates of consumer-rights groups, for example, as to what is realistic in terms of regulation. In balance, however, there is a definite feeling that a less belligerent attitude on the part of government would help to remove some of the "roadblocks" in the road to innovation.

U.S. patent system. Another area in which the government is involved with innovation is the U.S. patent system. In fact, involvement here is significant enough that we treat it as a separate subject.

Dr. Robert R. Pry, executive vice president of R&D at Gould Inc., Rolling Meadows, IL, points out that industry wants strong patents issued in a timely manner to minimize or eliminate subse-



Who gets U.S. patents?

Most of the U.S. patents granted to residents of other countries go to those in the so-called high-technology countries. For example, in 1981, Japanese residents obtained 31% and Germans obtained 23% of a total of 27,816 patents issued to nonresidents of the U.S.

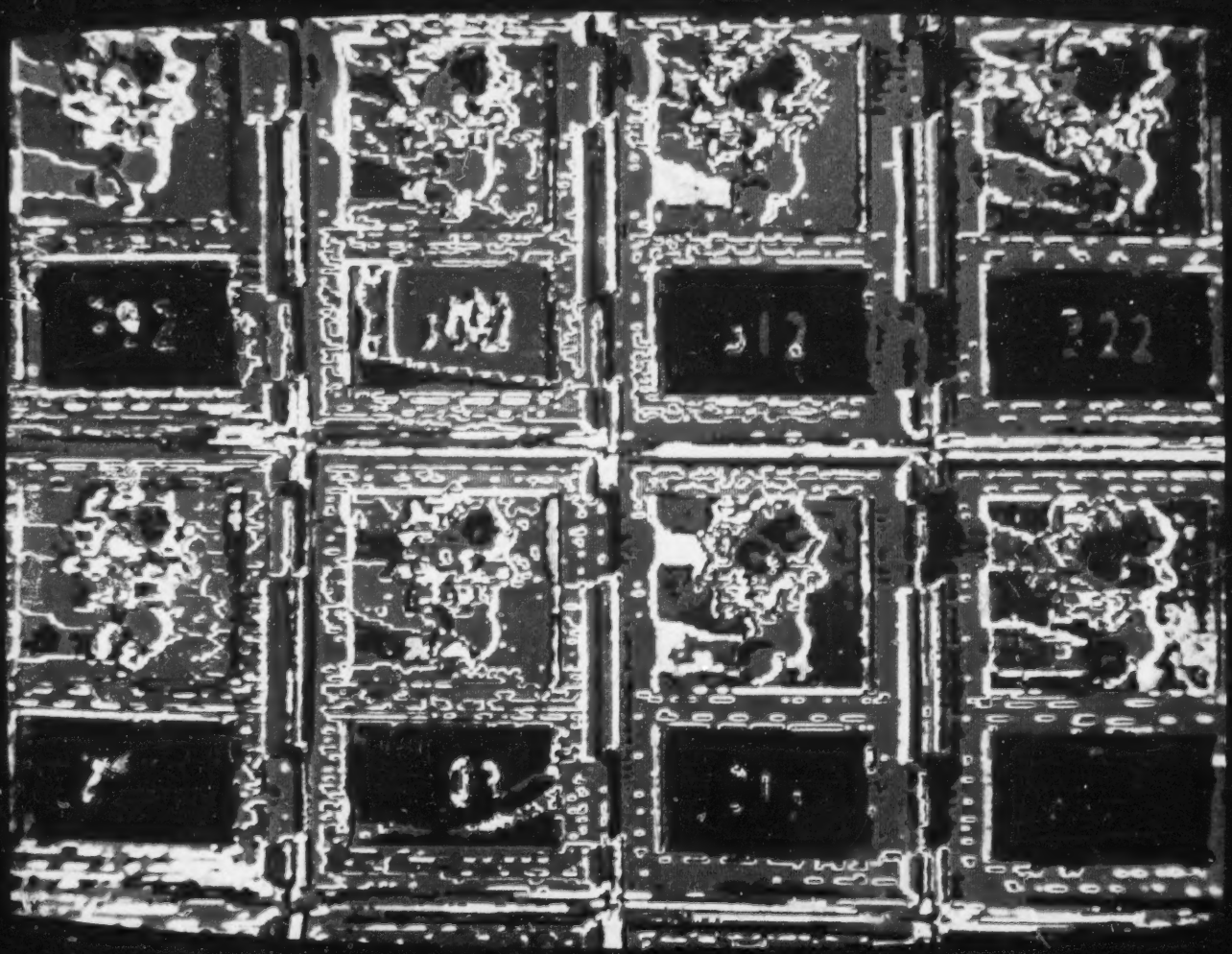
Another 9.5% of the patents went to residents of Great Britain, and more than 8% went to people residing in France. Almost 11% of these patents were divided among residents of 69 other countries of the world.

On the other hand, nonresidents often find it difficult to obtain patents in countries other than the U.S. For example, data obtained from patent offices in Japan and in West Germany show that relatively few nonresidents obtain patents in these countries. In addition, maintenance fees charged by patent officials in these countries increase patent costs substantially.

INDUSTRIAL RESEARCH & DEVELOPMENT

JUNE 1983

C8650-3 6/16/83



Electronic 'mail' goes where you go

Materials and techniques in communications technology

Using local area networks

News of importance to people in R&D

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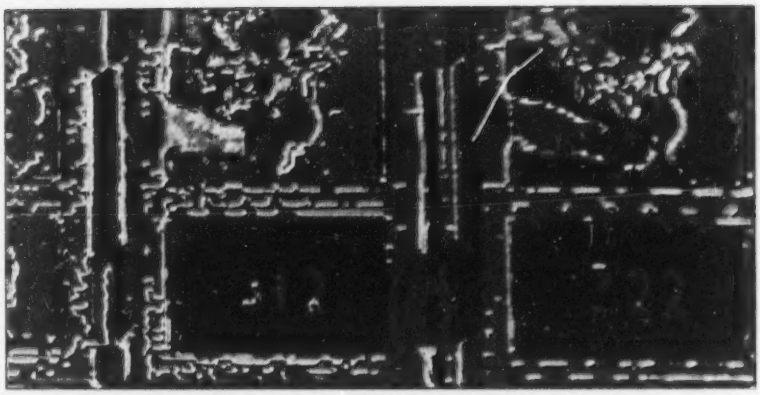
Electronic mail: instantaneous, private, 24-hr/day. **See p 82.**



INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $156.7-BILLION WORLDWIDE R&D INDUSTRY

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ABOUT THE COVER

Electronic mail is a fast-growing method of communicating rapidly and inexpensively. To send and receive messages, electronic mail users employ a conceptual "mailbox" that is activated by entering a code (usually the user's name) into a terminal. An article describing electronic mail begins on p 82. Other articles that describe materials and techniques in the communications field begin on pp 88, 96, and 108.

To achieve the cover image, a black-and-white photo of post office mailboxes was electronically "posterized" exclusively for *IR&D* with the Model 606H video quantizer developed by Colorado Video Inc., Boulder. The instrument uses gray-scale characteristics of monochrome video input signals to radically alter output linearity or to synthesize color signals from the different shades of gray.

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ABP BPA

NEWS OF SCIENCE AND TECHNOLOGY

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82 **Use electronic 'mail'; save time and money, get more work done:** Robert Heinmiller, Omnet Inc.; electronic mail systems allow you to communicate with your colleagues no matter where they are—and without having to pay long-distance telephone charges.
88 **Protocol software breaks new ground in LAN technology:** Gary L. Parr, assistant editor, *IR&D*; improving speed and efficiency of protocol software is the key to getting maximum use out of local area networks. A new front-end processor advances this technology.
96 **New thermoplastics perform extremely well in communications uses:** H.L. Thomas, associate editor, *IR&D*; development of strong, stable thermoplastics with excellent dielectric properties makes possible new designs for high-performance electronic and communications devices.
102 **Automated LC allows engineers to monitor ongoing processes:** R.A. Mowery Jr., Applied Automation Inc.; process liquid chromatography analyzes streams of reactants and products, permitting quick process changes at the time when they are needed.
108 **A voyage beneath the caps of your computer's keyboard:** B. Hengesh, Oak Switch Systems Inc.; economical and durable keyboards provide a wide variety of switching mechanisms to insure the operating characteristics and the feel needed for computers, calculators, and instruments.
113 **PBN material results in better GaAs crystals, IC device advances:** Robert L. Finicle, Union Carbide Corp.; pyrolytic boron nitride opens doors to growth of GaAs crystals and to development of advanced and effective semiconductor devices.

OPINION POLL RESULTS

R&D specifies for production

WHEN YOU pick up a component or reach for a compound in the course of research and development, your action may be in the form of a commitment. More often than not, the selections of the R&D workers are the ones which go into production.

This was revealed in our Opinion Poll on this subject. Complete results follow:

1. *Does your work involve design or development of products which do or could include components, supplies, or materials from firms other than your own?*
   a. Yes ..... 91% b. No 9%
2. *Are there others in your department whose work . . . as in question No. 1?*
   a. Yes ..... 89% b. No 11%
3. *Do people in your department select specific components or supplies for their suitability to the projects, or leave that up to another department?*
   a. We do it ..... 93% b. Others do it 7%
4. *Does the indication of a component or source in plans and specifications or the use of a component or source in a prototype or pilot batch lead to the use of the same manufacturer's material in the early production?*
   a. Always..... 10% c. Often 24%
   b. Usually ..... 54 d. No relation 11
5. *Does this tend to remain unchanged through most of production?*
   a. Yes ..... 44% c. No pattern 28%
   b. No ..... 12 d. Don't know 16
6. *Do people in your department have as much detailed information about possible components and supplies as they need, or can they get it easily?*
   a. Always .... 9% c. Often 23% e. Never <1%
   b. Usually .. 60 d. Rarely 8
7. *Do you know of instances when a better unit or material could have resulted from better knowledge of available outside sources and their products?*
   a. Many ..... 17% c. One 3%
   b. A few..... 71 d. None..... 9
8. *In your opinion, is the average scientist or engineer in research and development adequately prepared to specify components or suppliers for components to go into products that they develop?*
   a. Yes ..... 24% c. No 18%
   b. In some cases... 54 d. No opinion 4
9. *In the development of a new product or process, from whom do you obtain performance specifications?*
   a. Potential customer 11%
   b. Competitor's product 1
   c. ASTM, ANSI, NBS, etc. 3
   d. Military specifications 2
   e. Own ideas or opinions 19
   f. Component supplier 12
   g. Other 4
   h. Combination of a and b 15
   i. Combination of a or b with c or d 33

Measuring Viscosity?

SHEAR STRESS WITHOUT SHEAR RATE IS SHEER GUESSWORK!

Unless laboratory measurements are made under the same conditions that your product experiences in production/storage/use, your test results can mislead you. The shear rate of your tests should simulate the shear rate of actual conditions, or else they won't tell you any more about the product's performance than measurements made at the wrong temperature or pressure.

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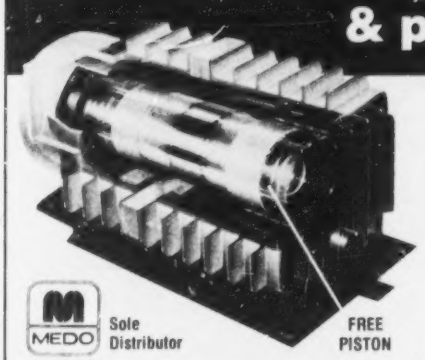

"Free piston" design makes the Médo linear-motor-driven vacuum pump/air compressor totally different from all others. With only one moving part, it not only uses less power than anything else that pumps the same amount of air, it's also quieter (sound levels 40-50 dBA/m), smaller, lighter, longer lived, and more reliable. It does not need oil, cannot spark, and an overload cannot cause coil burning. Applications include robotics products, vacuum pickups, vacuum sensors, air bearings for magnetic tapes, health and medical aids, aspirators, cosmetic and beauty aids, septic tank blowers, and spray guns.

Ten standard models usable as pumps or compressors range from 0.28 to 1.94 CFM, 20 to 95 W (AC) input power, 1.8 to 10.8 lbs., and approx. 4.8" x 3.56" x 3.25" to 8.8" x 5.4" x 6.1". Two vacuum-pump-only models can produce vacuums of -7.8"hg. and -24.4"hg., use 40 and 70 W, weigh approx. 6.4 and 11 lbs., and measure approx. 8.2" x 4.1" x 5.9" and 8.28" x 5.38" x 6.1". Customization available on large orders.

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